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Vol. XV., No. 1. 1889. Whole No. 48.

PROCEEDINGS

OF THE

UNITED STATES

NAVAL INSTITUTE.

VOLUME XV.

EDITED BY

J. B. BRIGGS AND RICHARD WAINWRIGHT.

PUBLISHED QUARTERLY BY THE INSTITUTE.
ANNAPOLIS, MD.

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THE PROCEEDINGS

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

NAVAL RESERVES, AND THE RECRUITING AND TRAINING OF MEN.*

By Lieutenant Sidney A. Staunton, U. S. N.

Notwithstanding the differences in regard to political constitution, social organization, and international relations, which exist between the United States and the European countries whose naval systems have been reviewed, copious and valuable lessons may be obtained from a study of those systems. We do not wish in America to play at preparation for war merely because its necessity is not every day brought home to us by the serious danger of a national quarrel, or the cankering hostility fostered by schemes of national revenge, and we should not beg the question by putting aside criticism of our armaments and methods with the cheerful optimism of believers in perpetual peace. There are only two logical courses to pursue. One would be to disband the Navy and save the annual charge of fifteen millions. The other is, to effect the changes that are required to make it, in proportion to its strength, equal in fighting efficiency to any service in the world; and that these changes are many and important will not, I think, be denied.

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* One of a series of lectures delivered at the Naval War College, Newport, R. I., October, 1888.

The first course is too improbable for discussion. The second has, we hope, so far as the material is concerned, been already fairly begun; and for the purely military questions of recruiting, training, and reserves, we, who are naval officers, should in my opinion neglect no opportunity of influencing public opinion and leading it into the proper channels. It is all, to us, a matter of personal and professional as well as patriotic interest; for, in the event of foreign war, the Navy would have to meet the first attacks, and it is highly important that we should have the men and means to meet them with success.

Compulsory service in our country is out of the question. The sentiment of the people is opposed to it, and it has been only with some difficulty enforced in time of war; moreover, it is undesirable. But the fact that we do not enforce military and naval service upon our citizens in time of peace, does not render less valuable the study of the systems of training and instruction of men in the countries where this is done. Obligatory service removes all difficulties in the way of recruiting; the law fixes the age and manner of entry and the duration of service. The administration therefore has only to consider the best method of forming the men into a skillful and effective *personnel*. A very difficult part of the problem which exists in England and America—that of inducing men of proper age and character and capacity to enter—is settled in advance, and the obstacles which the uncertainties of a voluntary service constantly throw in the way of thorough training are not encountered. It may fairly be assumed that a scheme for the fundamental training of men from a maritime inscription would be more thorough, comprehensive and efficient than a similar scheme laid down for the training of a force of volunteers.

There would be no hesitation in the first case about demanding work or enforcing discipline; none of that fear of discouraging future enlistments which might hamper the programme in the second. This consideration adds to the value of the foreign systems of training, for purposes of comparison or imitation; *i. e.* it adds to their value as models, which are probably worthy of imitation whenever the conditions of our service will permit us to follow them.

Again, no service is entirely compulsory. For a very important and essential part of its *personnel*—the veteran petty and warrant officers of mature age—it must depend upon the willingness of competent men to remain in the service and make it their career. This class is re-enlisted in part from those who begin as volunteers—*i. e.*

as boys and apprentices enlisted for training—and in part from those who voluntarily continue after the expiration of the obligatory period. The burden of a compulsory service must be uniform, or it would not be tolerated. Selected men cannot be held arbitrarily to a term of active service extending beyond that which is required of all. If their services are desirable, the State offers them inducements to remain; and from this point all the features of a voluntary contract appear. These inducements are bounties for re-engagement, increased pay, prizes for excellence and good behavior, tenure of ratings obtained, desirable positions on shore in the public service, and retiring pensions. It is essential to the stability and character of a service that a certain proportion of these continuous-service men should be retained; their absence is, as has been already pointed out, a defect which a compulsory system cannot remedy; and some of the best illustrations of that careful and well considered arrangement of rewards and compensations which is calculated to effect this end at the least cost to the public treasury, are furnished by countries whose systems have been described.

In England the political and social institutions are much more nearly like our own, and all public service is voluntary. We may without hesitation draw examples from her methods; for there are probably few desirable features of British naval administration that could not be copied in the United States with practically the same measure of success.

Surveying therefore the whole field of naval progress, a good many suggestions present themselves for consideration and discussion. Some of them are worthy of a trial, and I am confident that a certain number might be adopted with enduring advantage to our Navy.

First, with regard to the entry and training of boys. We enlist them now to serve until the age of twenty-one. We lose command of them at precisely the age when there is the greatest necessity of retaining it, at the most critical time of their lives, when the sense of manhood's independence and the natural desire to escape from an apprenticeship which, at its best, like all educational careers, is frequently irksome and fatiguing, is unchecked by the wisdom that a few more years would bring.

It results that we lose the majority of them; and the cost of training the whole, divided among those who remain in the service, amounts to an alarming sum for each man so obtained. In England the training system which keeps boys in the service until the age of 28 or

30, has revolutionized the character of the *personnel*. In America the training system, which lets boys go at 21, has appreciably improved but has not radically changed the character of our crews. We have a training system and an untrained service, and the results are not likely to change while the present system continues.

We should keep the trained boys in the service until their habits are formed, until they have thoroughly taken the shape of the naval mould and became entangled in naval associations, and are much more likely to seek a re-enlistment, with its present advantages of bounty and future advantages of pension, than to attempt to make new beginnings in untried fields. If there are any objections to establishing such a change in the relations of our naval apprentices to the service, I do not perceive them. It would be based, as the present service is, upon a voluntary contract which, if beyond the comprehension of the boy himself at the early age of entry, would be fully understood and appreciated by his parents or guardians. The training should be for the good of the Navy, not for the good of the boy. It is partial, not general; it applies to individuals, not like a system of public instruction to the mass of the people; and the State which bestows it has an undoubted right to make such conditions of future service as will afford a return for its cost. A logical feature of the system would be the obtaining of discharge only by purchase, *i. e.* refunding to the State, which is to lose the service of the boy, the expense of his training. This purchase money would be a certain sum for each month spent in the training-ship; would reach its maximum at the end of the period of training proper, and would then gradually diminish to the end of the term of service. Such a condition would discourage inconsiderate entry, would diminish the number of applications for discharge, and would add stability to the training system.

Of course it is admitted on all sides that we must make a number of new departures in the training of specialties and in the composition of our crews. We shall have a gunnery-school and a torpedo-school for men. We shall train divers, and shall either train or obtain from civil life a permanent class of machinists, electricians, and artisans in metals. The importance of the gunner is much increased, especially if he is to be charged with the care of torpedo stores; the functions of the boatswain and carpenter are greatly diminished, and the day of the sailmaker is past.

The adjustment of the different questions relating to the engine-room force is second to no other matter in its importance to our future Navy. It is very evident that our present system of taking firemen and machinists from private life is fatally weak. They dislike drill and shun it when possible, regarding great guns, rifles and cutlasses as instruments of torture. Their object is to maintain themselves a separate class on board ship, with only such duties and obligations as they would have in a merchant steamer.

It is essential that this sentiment should be destroyed, that they should be given enough military training and drill to enable them to form, when needed, an effective part of the combatant force, and to imbue them with proper *esprit de corps*. Probably this may be accomplished by entering at least a part of the firemen and machinists at an early age for training, by retaining them in continuous service, by enforcing their military drills in the cruising ships and the naval barracks—which it is to be hoped will before long take the place of receiving ships—and by admitting them to competition for prizes in target-firing with great guns and small arms.

A notable feature of the administration of this part of the *personnel* in the navies of continental Europe is that machinists, trained in industrial schools and workshops, with the rating or rank of petty and warrant officers, perform all the watch and subordinate duty in the care and management of engines, and are often in immediate charge of the machinery of small ships. The number of engineers with the rank of commissioned officers is very small. In 1886 there were serving in the entire German fleet of twenty-four ships in commission, in different parts of the world, only twelve engineer officers. In all the ships the subordinate duty was done by machinists, and in twelve of them the machinery was in responsible charge of machinists.

These men are given a sufficient education and thorough practical training, have regular advancement, and a secure tenure of the positions which they reach.

Opinions which accord with this practice are strongly supported in England. Since 1863 the number of engineer officers in the British Navy has been diminished from 1418 to 687, and there have been introduced 187 chief engine-room artificers, and 976 engine-room artificers—a total of 1163—to perform the subordinate duty.

A leading professional paper said in December, 1887: "There is another subject that we should like to see taken up and thoroughly thrashed out by the Council of Naval Education, and that is, our present system of finding suitable people whose sole business it is to look after the engines of our men-of-war. Our own feeling is that we are going all wrong in flooding the service with such numbers of expensively trained young gentlemen. We do not want the class we are training for the ordinary work. We should have a small corps of highly trained engineers, but the main body should not be brought up in the manner they are at present. We want our engines driven with skill and intelligence; but anything beyond this is a luxury, and one that leads to all kinds of complications. The engine-room artificers were introduced as an attempt to meet the want we speak of, but they are not altogether satisfactory, although many are excellent workmen and valuable assistants. We should like to see the establishment of a corps of good practical men for driving our engines; men who might rank, if rank is necessary for them, with our warrant officers; paid well enough to enable us to get thoroughly respectable and intelligent men, who would be competent to effect all ordinary repairs, etc., to the engines; men of the same stamp as those who run our ocean steamers at high rates of speed with such continuous success.

We believe that the system, under which the staff necessary for working the engines of H. M. ships is provided, stands alone among navies."

The editor evidently did not include the United States Navy in his comparison.

It is not improbable that the ultimate solution of the question in Great Britain will be the early selection and naval training of these men, practically as it is done in Italy and Germany.

Such a system would have its advantages for us. I do not assert my opinion that it is indispensable, but I believe that it would be much better than taking machinists from private shops and steamship lines, which naturally make every effort to retain their most skillful and reliable men, releasing to other employment only those of secondary value. A school established at New York which should take boys of good character, good physique and mechanical aptitude, give them a course in mathematics to plane trigonometry inclusive, fundamental science and a knowledge of drawing, and at least three years solid practical apprenticeship in the machine shops of the navy-yard, would turn out a class of young men well fitted to begin active service in cruising ships. Their apprenticeship in the navy-yard shops should be supplemented by experience in running machinery in tugs and other service vessels, and at steam trials. These men should enter active service in the lowest grade of machinist, and have ahead of them four or five promotions in grade and responsibility, and as many rates of pay. They should have in the senior grades the rank, pay, and consideration in berthing, messing and privileges of our existing warrant officers, and should be eligible to promotion to the rank of assistant engineer.

I think a good many officers will agree with me that the present system of graduating assistant engineers at the Naval Academy is surrounded with faults and objections. They are admirably prepared to take up advanced courses of real naval engineering, *i. e.* designing and construction; but for engine-drivers the mark is overshot. They have had too much of the classroom and too little of the machine shop, and they are inferior in practical knowledge to men much beneath them in mental training. Moreover—a very serious thing in a ship filled with machinery—they add nothing to the strength of the working force for repairs. The class of men that is recommended to take their places would be trained first and foremost as practical workmen, accustomed to manual toil, and ready at any time to labor at the lathe or bench.

The tenure of ratings, and the regular advancement of men from one to another, subject to certain qualifications of service and capacity, is a subject which the study of foreign systems forces upon our attention. Our own service is somewhat chaotic in this respect. As a rule, the rates in a ship are the creations of the commanding officer, who has power to "reduce any rating established by himself," and who, upon turning over his command, effects a general disrating in order that his successor may have the same free scope. At the pleasure of the commanding officer, the chief petty officer of a ship may be disrated to landsman, and a landsman from the crew may be advanced to his position. Boatswain's mates, captains of parts of the ship, and coxswains are constantly made and broken.

I do not wish to be understood as criticising the manner in which this power is exercised by commanding officers. I believe it is, in the majority of cases, employed with the best judgment, and generally with a conscientious sense of the obligations that are joined to it. I am perfectly aware that no officer, until he has had some experience as first lieutenant or in command, can fully appreciate the difficulties that surround this question in a service recruited from odds and ends of all humanity, as ours has been; and I know that often, on account of the absence of better material, it has been necessary to drag an apprentice-boy, or even a newly caught "beachcomber," from his obscurity and make him a petty officer. But the system is a bad one, and the fact that arguments to sustain it can be drawn from the condition of the service is a powerful argument for the reform of that condition. It is true that good, well-behaved petty officers are rarely disturbed in their rates, but it is also true that they have no certain right of property in them which they can assert and defend, and that they can be deprived of them at any moment without reason given or charges preferred, the regulation merely requiring the fact to be noted in the log.

This is as well understood on the berth-deck as it is in the cabin, and it diminishes the ambition to obtain a petty office and the pride in the possession of one. When a man may be elevated from the ranks one day and degraded to them the next, he looks with indifference upon his ephemeral honors, and does not exert himself materially to get them or to keep them. The fact that petty officers do not have sufficient control and command over their men, and do not lead and influence them to subordination and good behavior, has constantly been deplored. How can it be otherwise when our system of ratings keeps the level of the whole service at the level of the mass of unrated men? Our petty officers should be required to have more capacity, and should be clothed with more authority and given more importance. They should constitute a class apart. The distance between the rated and unrated *personnel* should be greater than it is, and that between the rated *personnel* and its commissioned superiors should be less. So much may be demanded from any individual in the crews of our new ships, that the numerous different grades of capacity and intelligence must be recognized, encouraged, rewarded and preserved. A man who by his ability and faithfulness has obtained a rate should be deemed to have acquired property in that rate, similar in kind, if less in degree, to that which an officer enjoys in his commission.

It ought to depend upon certain qualifications of service as well as of capacity, be conferred by a board, and taken away only by a board or by the sentence of a court-martial. I do not mean a board of juniors serving in the ship with the man to be rated, but a Board of Ratings, established for the station or the squadron, and working under the provisions of a general scheme.

I have not overlooked the fact that our existing regulations provide in certain cases for enlistments of petty officers, thereby conferring rates which cannot be reduced by a commanding officer. But the conditions are onerous and difficult to fulfill. In the first instance twelve years' continuous service are required, three good-conduct badges must also be had, and very high marks must always have been obtained. It is anomalous that, in a service whose requirements are low and discipline mild, where a man may be rated to any position in the crew without previous service or certified qualifications, a seaman can obtain a certain, assured, and permanent position as a petty officer, only after a period of service amounting to a third of his active lifetime.

More thorough training and continuous service would supply the men for the permanent ratings of all kinds; and this, I think, is one of the advantages that we may confidently anticipate in the future organization of our naval crews.

Trained boys need not be depended upon exclusively to fill all vacancies in the seaman class; but no foreigners should be enlisted at home or abroad, and no men beyond the age of ready adaptability to a new life should be taken. Above all, no men who have failed in other pursuits should be entered, to make one more failure at Government expense. A service, as attractive to men as ours can be made, need not go begging for recruits.

A board of officers recently in session at the Navy Department, to examine the question of rating and pay, has given the subject careful consideration, and has made in its report important suggestions. Generally speaking, they have been in the direction of increasing the number of rates or grades of rates in a specialty, in order that promotions may be more frequent, and that distinctions may be made between slight differences of professional skill, or, where the skill is the same, that better conduct may be considered.

The board recommends the creation of a special corps of marksmen; the candidates for the requisite training to come from any specialty stationed in the battery in action, and proficiency to be rewarded by a certificate and three dollars per month extra pay. The value of accomplished marksmen for firing the guns of the principal and secondary batteries is forcibly presented in the report. A better class of machinists, with better pay, is also recommended. Four different rates are suggested, to be filled by practical men, capable of managing the high-power steam machinery of our new vessels, who shall have an assured place in the Navy and good pay.

RESERVES.

The same changes in our system of recruiting and training which are recommended above to improve the character of the active service, might also, under regulations similar to those of Great Britain, supply a class of naval veterans for the Revenue Marine, and the Lighthouse, Life-Saving, and Coast Signal Services.

Attempts have been made, and have of course been strenuously opposed by those whose positions would be affected by a change, to bring these services under the control of the Navy Department. The Revenue Marine is essentially a naval force, and its duties need not infringe upon the fiscal responsibilities of the Treasury. The other services do not touch these responsibilities on any side. They are all more than semi-nautical in their character, and when, to the administrative reasons for a change of control, is added the military reason that a valuable body of naval reserves could thereby be maintained without additional cost, the advocacy of a transfer is much strengthened. The close association of these services to the Navy would result in advantage to both.

The Whitthorne bill, without making any mention of such a change, permits the enrollment of these men in the Naval Reserve. Whether they remain under the Treasury or pass to the Navy Department, they are equally under the command of the President, and it is important that they should be so instructed in warlike exercises as to form an available force in case of need.

But these public services are small, and the number of trained veterans flowing from a volunteer service is limited; therefore we must look to outside sources and untrained men for the large body of our naval reserves.

The Royal Naval Reserve of Great Britain fills precisely the popular idea of a naval reserve, *i. e.* an enrollment of men from the mercantile marine, with no organization, and not much drill, large dependence being placed upon those qualities which merchant seamen are supposed to possess merely by virtue of their seafaring life. As it may seriously be questioned if the Royal Naval Reserve would prove in time of war to possess the value generally attributed to it, it is well to investigate it carefully before we assert it to be a desirable example.

The First Class Reserve (recruited from seamen) does not increase. Between 1881 and 1884 it actually diminished from 11,990 to 10,519; while the Second Class Reserve (recruited from fishermen) increased from 5416 to 6888. The Third Class (boys) is small, varying from 119 to 143 between the same years.

Although the number of men employed in the mercantile marine is over 200,000, competent judges estimate that the Reserve force enrolled from this class can never exceed 15,000 men. Vice-Admiral Phillimore, reporting in 1880, made the following analysis:

Total number in crews of merchant shipping, according to Board of Trade returns of 1875	207,000
Deducting persons "other than seamen," viz., officers, apprentices, etc., engineers, firemen, artificers and servants, numbering	125,000
Leaves seamen, able and ordinary	82,000
Deduct foreigners, numbering	16,000
And there are left of English seamen	66,000
The number of these seamen who, on account of desertion, imprisonment, misconduct, sickness, death, or other causes, do not complete their engagements, is about	38,000
Leaving apparently as the number from which the Reserve must be recruited	28,000

Admiral Phillimore considered that, when the age limit and physical qualifications were taken into account, 12,000 was a good number to enroll from 28,000 seamen. Therefore it appears that the system has been fairly successful as far as the enrollment of men is concerned.

But the number of officers has always been far short of that allowed. In 1877 there were only 212; among them 114 lieutenants, of whom 59 had failed to comply with drill regulations, and 96 sub-lieutenants, of whom 44 had failed to comply. In 1880 there were still fewer officers, and in 1888 there are 264.

The reports of the Admiral Superintendents, while pointing out certain defects, are rather favorable, as might be expected from their official connection with the Reserve. Admiral Tarleton, reporting in 1887, thinks "the act has fulfilled the intention of its framers." He thinks the shipowners have suffered no inconvenience from the working of the drill regulations, that the prejudices of merchant seamen against the Navy have been abated, and that their character has been improved. He speaks highly of the Scotch and the Scotch islanders who have joined the Reserve. But he admits that the vital question, what the Reserve will amount to in time of war, must remain open till tested.

Admiral Phillimore (1880) considers them "a very fine body of seamen, the leading and best men of our merchant ships."

But this sentiment of general approval of the system and its results is not unanimous. There is plenty of testimony to show that the men are not sufficiently drilled, that they are not sufficiently disciplined, and that all sorts of frauds and impositions are attempted to obtain the retainer and the drill-money without rendering to the Government an adequate return. Several officers who have had to do with the Reserve, either in command of district or drill-ships or in charge of batteries, find serious fault with the degree of efficiency reached in the drill.

There is not enough drill to teach the men the use of modern weapons, and the periods of consecutive drill are too short. As a matter of fact, the Reserve drills have mostly been had with old weapons quite out of date for fighting ships; and the deficiencies would be still more marked if it were attempted to make the men qualify with new guns and carriages. The great trouble is that with no organization there is no *esprit de corps.* Each individual stands alone, takes his drill alone, and forms his own standard, and derives no strength or benefit from the community of sentiment and purpose, the exaltation of patriotic feeling, the respect for authority, the love of approbation, the resistance to fugitive impulses—in one word, from the discipline, moral and mental, that organization alone can give.

A Reserve, like any other military body, should have every available artificial aid. No dramatic quality should be lacking, no effective appeal to the eye or ear should be neglected.

Pride in the reputation of one's corps, in individual bearing, in excellence of drill, in the care of arms, fondness for the glitter and circumstance of military life, ought all to be made useful. The local pride of county, town or seaport should be skillfully handled to produce the maximum results. All this is possible with organization —impossible without.

The availability of the Reserve in time of need is a serious question. Mr. John Williamson, secretary to the Liverpool committee for inquiring into the condition of seamen, says, that of the eleven or twelve thousand merchant seamen belonging to the First Class Reserve, not more than three or four thousand would be available within the first six months of a war. A war might be finished before the end of that time; and it would follow, in that event, that the total annual retainer paid would amount, for the men actually utilized, to from 90 to 120 dollars apiece, which with drill-pay, pensions, etc., would make the Naval Reserve a pretty expensive luxury. Many officers will agree with Captain Fellowes, who said in 1869: "The Naval Reserve should, in my opinion, be a body of men on whom you could place your hands in twenty-four hours."

Captain Bedford Pim, R. N., then a member of Parliament, moved in the House of Commons in 1878, "that in the opinion of this House the Royal Naval Reserve is not adapted for the present requirements of the nation, and should at once be superseded, or at least supplemented by a large increase of Naval Artillery Volunteers; and that in order to secure efficiency, such men should be trained on board seagoing gunboats stationed around the coast, and available for service on the shortest notice." Captain Pim supported his motion by a speech, in which he asserted that the mercantile marine did not contain more than 20,000 real British seamen, that the 12,000 or 13,000 Naval Reserve then enrolled were all that were really available, and that those men could not be spared in time of war from the merchant service, where their ability and loyalty would find free scope and ample occupation in keeping up the necessary commercial communications. He said that the Reserve was a "snare and delusion," and that the nation was paying for it a million dollars a year, when for the same money the services of 30,000 Royal Naval Artillery Volunteers could be obtained; and he eulogized the zeal and capacity of the men of this latter corps.

Captain Pim does not stand alone in these opinions. It is very evident that the Royal Naval Reserve owes its support more to the traditional sentiment that sea-experience, no matter how or where acquired, is the most important qualification of a fighting man, than to a careful and unprejudiced study of the conditions and demands of modern warfare.

Those who incline to the acceptance of these views will recognize the fact that an enrollment of our merchant seamen will not be a certain dependence, and that we must look to the organization of local bodies like the batteries of the Royal Naval Artillery Volunteers for a reliable and well-trained Reserve.

The subject has received considerable attention during the past year in the Navy, in Congress, and among merchant sailors and yachtsmen. The members of the latter class in New York have advanced schemes for the formation of a Reserve, which propose to enroll themselves and their vessels, subject to a call in time of war; but these schemes have not been founded upon sound principles of military efficiency. The Seawanaka Yacht Club proposed an enrollment of officers who were to receive occasional theoretical instruction. There was to be no enrollment of men as individuals, subject to either State or National control, and no organization or training of men. The idea was merely to enroll a class of yacht owners and captains who would all hold commissions. Titles, uniforms, a distinguishing flag for their yachts, and immunity from certain Treasury regulations were suggested; but the painstaking, laborious and methodical details of organization and drill which are indispensable to the training of men for the demands of modern warfare, did not enter sufficiently into their plan.

The committee, of which Commodore Elbridge Gerry was president, presented a scheme which did include the enrollment of men, but there were no adequate provisions for organization and instruction, to make this enrollment practical and useful.

It is to be hoped that fuller study and agitation of the subject may change the attitude of the New York yachtsmen, and induce them to look at this matter in a different way. Gentlemen of wealth, leisure, position, and nautical experience, they ought to be the mainstay of such a movement; and giving their aid and support to efficient organization, place themselves at the head of a Naval Reserve thoroughly trained for any exigency of war. Their capacities and opportunities are too valuable to be wasted in naval dilettanteism.

The Whitthorne bill will, in time, probably become a law. Its provisions relating to the *personnel* comprise:

1st. The enrollment of a Naval Militia, to include that portion of the general militia of the country engaged in seafaring occupations (including river and lake traffic) and in those which are allied to seafaring pursuits.

This enrollment will emphasize the fact that the Navy is an important branch of the public service, and that its efficiency is jealously guarded; and will identify the people with its interests, by assigning to certain classes of citizens the obligation of naval instead of army service, and the duty of strengthening the naval establishment in time of war. No such enrollment or division of duties has ever been made, and there exists no provision or precedent for the assignment of naval quotas to the several States. During the Civil War it was with great difficulty that men could be obtained in sufficient numbers to man the fleet; and it was only by adjustment and arrangement between the War and Navy Departments, by which men drafted for the Army could be transferred *with their consent* to the Navy, that the end was attained. The terms of this arrangement were affirmed by a law enacted in 1864; and another act, passed the same year, credited States upon their quotas with the number of their citizens serving in the Navy. But none were obliged so to serve.

It is very evident that this defect in our militia regulations ought to be remedied.

2d. The organization by the States of batteries of Volunteer Naval Artillery and crews of Volunteer Torpedo-men, to be recruited from the Naval Militia, and from others who may desire to serve in them. The strength of these units of organization is fixed by the bill. All details of organization, uniform, titles and instruction are left to the discretion of the Navy Department, but must be the same throughout the several States and Territories.

A State may or may not organize Naval Reserves under this act. As to this, there is nothing mandatory in its provisions. If they *are* organized, the United States is to provide arms, equipments, guns and vessels, if practicable, for purposes of instruction, and may detail commissioned and petty officers of the Navy to act as inspectors and instructors.

The State commissions all its Reserve officers. There is a provision that officers holding these States' commissions may be commissioned also by the President in the same titles and grades, if they so desire, and meet the requirements of a naval board of examiners. This United States commission would not alter the relation of an officer obtaining it to his State, or his position in the Reserves, and would carry to him no compensation. It would in effect be only a distinction —a certificate of competency—bestowed upon an officer whose qualifications had been ascertained and placed upon record. But in the event of war, these officers would naturally be looked to for the most important and responsible service.

3d. The calling out by the President of these bodies of naval volunteers for annual drill, under the control of the Navy Department and the immediate direction of naval officers. This is a new power, but its possession and exercise are essential to the efficient training of a Naval Reserve. The country cannot furnish the means of instruction to every State. It is not a question of a few hundred stand of arms, like the equipment of an infantry battalion of militia, but one of ships and guns; and modern ships and guns are too expensive to be duplicated for purposes of training. They are even too expensive to be duplicated for the training of the regular force. Both regulars and reserves must receive their final and most valuable training with ships and guns provided and kept in readiness for war, *i. e.* in the battleships and cruisers of the fleet.

If the whole training of the Naval Reserve organizations were left to the States, the best that the Government could do would be to place at their disposition, for brief intervals of time, the means to accomplish this duty. But in such cases it would be necessary to keep naval officers in immediate control and command of this material, since it cannot be supposed for an instant that a modern cruiser, with all her intricate and costly machinery and fittings, would be allowed to pass out of the responsible charge of professional men. The State authorities might lay down a programme of exercise, but the officers in command of the ship placed at the disposition of the State would necessarily control all her movements, and would to a certain extent exercise military supervision over everybody embarked in her. There would be a conflict of plans and authority, and consequent failure.

Following the intention of the proposed legislation, the idea would be that to all the volunteer organizations, both artillery and torpedo, small arms should, upon their formation, at once be supplied; and the men would become familiar with these weapons and acquire skill in their use in their drills at home under their own officers. As much valuable primary instruction can be given, and some of the cardinal principles of gunnery taught, by means of a battery of obsolete cannon, such drill batteries might be erected at central points, accessible to several volunteer organizations. The converted B. L. Parrotts would be preferred for this use.

The drills at these batteries would also be those of ordinary occasion, carried on by Reserve officers under the direction, if such had been detailed, of naval gunnery instructors.

The torpedo-crews would be given material for instruction in the elementary principles of mine-laying. The depots and stores for the defense of ports, which, if any adequate system of coast defense is adopted, must be established at every principal port and sea entrance, would furnish ample material for the training of these men. All the above drills would be had at convenient times during the year, and would be under State control, subject to the provisions of the general programme of instruction.

The scheme of annual drill under United States authority would probably begin with the establishment of certain points on our coasts as rendezvous, to each of which would be summoned the Reserves from several States. There they would meet ships and torpedo-boats, and, wasting no time upon details which they had been able to master at their homes, would devote the entire period of exercise to their new and enlarged opportunities. The difficulty of getting sufficient volunteer time to master the laborious details of modern warfare has already been commented upon; and I do not think it will be questioned that more is likely to be accomplished in a programme laid down by the Naval General Staff than in one laid down by State authorities. Add to this advantage the generous emulation between the organizations of different States, and the benefit of a close touch with the regular service, and it seems very clear that this annual drill under central authority is a wise and necessary provision. If, as is not improbable, the course of our naval progress should lead to the reduction of our foreign squadrons and the increase of the home squadrons, Atlantic and Pacific, retaining in them all our best and newest ships, and making them centers of training for both officers and men, this Reserve would supply enough men to enable us to mobilize the entire fleet each summer, putting all ships into commission, and carry out a series of manœuvres, tactical and strategic. It may be supposed, by way of illustration of the possibilities of such a scheme, that the Atlantic fleet, mobilized early in the summer, would spend a month in the Gulf of Mexico, training the Reserves of the Gulf States; a month in the Chesapeake with the Reserves of Georgia, the Carolinas, Virginia, and Maryland; and a month on the Northern coast with the Reserves of the Middle and New England States. The training of the Lake Reserves would be made the object of special arrangements.

4th. The enrollment for terms of five years of a Navigating Naval Reserve, consisting of officers, seamen, engineers and firemen from the merchant service and other nautical and aquatic pursuits, who are American citizens, and who qualify before a naval board.

They are to report to a prescribed naval authority once a year, and upon establishing their continued fitness for duty are to receive a retaining fee.

This body is to be a strictly National Reserve, from first to last under central control. The bill provides that its members may receive a course of training, but there is no organization, and more benefit would be anticipated from the qualities acquired in their every-day occupations than from what it might be possible to teach them in desultory and unsupported instruction.

They would be expected in time of war to do the deck and navigating and fire- and engine-room duty of the auxiliary cruisers, provided for in other sections of Mr. Whitthorne's bill. The guns of such a cruiser would be manned by a battery of Naval Reserve Artillery, and the whole would probably be commanded by a regular officer. This proposes to form the crew of an auxiliary cruiser of two elements; the one trained to a seaman's calling, but not necessarily knowing anything of the use of arms; the other trained in the use of arms, but not necessarily knowing anything of ship management. It is not an ideal system, but it seems the best we can do. It contains elements of strength, and the elements of weakness are those that every day of service would rapidly diminish. It is, at any rate, a practicable scheme and promises something.

The enrollment of this Navigating Naval Reserve is the concession which the bill makes to the qualities, pure and simple, of the merchant sailor; and I think the concession is sufficient. It practically defines the value and weight which these qualities alone have in modern warfare, and it anticipates ready military support in only that degree that military organization and training have been complete and effective.

Such is a hasty sketch of the principal provisions of the Whitthorne bill. I think it may be honestly said that the more fully they have been discussed and understood, the more has popular and professional opinion inclined to their support. One positive assertion may safely be made. The success of the measure, if it becomes a law, will depend upon the good-will of individuals. The States need not organize Reserves unless they choose to do so. The United States has no coercive power; and if organizations failed to obey the President's call to drill in time of peace, there would almost certainly be no further action in the matter. The bill provides a scheme for a volunteer movement, and appropriates money to equip and maintain those who consent to the scheme and conform to its conditions. If the people of the seaboard and lake States are sufficiently appreciative of the danger of inaction, and sufficiently patriotic to prepare for defense, they will do this and give the bill a fair trial.

A uniform system would, I think, be acknowledged by any competent naval authority to be a necessity; and this is the only system which has been elaborated and placed before the country in an authoritative way.

Massachusetts has taken the lead in State action, and has passed an act authorizing the formation of a naval battalion of volunteer militia, to be raised "when the United States Government is ready to furnish arms and equipments and a vessel of war." This act was passed chiefly, if not wholly, through the exertions of the Dorchester Yacht Club, which is entitled to much credit for its comprehension of the practical conditions and demands of a Naval Reserve.

It is to be hoped that other States, both sea- and lake-board, may take the matter up with zeal and energy as a question of public pride and public policy.

Considerable encouragement has come from the Northwest, where the bill is regarded with much favor. Chambers of Commerce and the Lake Carriers' Association have passed resolutions endorsing its measures. A desire has been manifested for the establishment on the lakes of training-ships like the St. Marys at New York.

There are plenty of lake steamers to form a powerful fleet—iron ships of the strongest build, for carrying ore in bulk and fighting their way through ice. Batteries for these ships stored at the principal ports, depots of mines to defend the harbors, and an efficient Reserve to manage both ships and mines, would furnish the means to do much towards guarding that important frontier in the event of trouble, and perhaps even to undertake offensive warfare.

In bringing this series of lectures to a close, I will recapitulate the leading suggestions that I have ventured to offer touching our own service:

For Recruiting and Training.

1st. The enlistment of our apprentices for a much longer period, and the adoption of such regulations respecting discharge as shall tend strongly to keep them in the Navy.

2d. The enlistment of no man for general service who is not an American citizen and under 21 years of age.

3d. The extension and elaboration of special training, with a great increase in the number of rates and differences of pay.

4th. Greater distinction between the petty officers and the unrated men; greater security in their rates for the former, and regular permanent advancement for those who are deserving.

5th. The establishment of a special school for the training of a superior class of machinists.

FOR NAVAL RESERVES.

1st. The employment of veteran naval seamen in the semi-nautical public services, and their maintenance as a first reserve.

2d. Volunteer naval artillery and torpedo bodies, organized and trained substantially as described above.

3d. Enrollment of the best men and officers of the mercantile marine, with a special view to their service in auxiliary cruisers.

These suggestions, if carried into effect, may not solve our problem entirely and satisfactorily, but they would doubtless do something towards its solution. They would bring forward better suggestions, and both old and new mistakes would be corrected.

Substantial progress must be gradual, but it must have a beginning notwithstanding ; and when new departures become necessary, no time should be lost in adopting them.

NOTE.—Since the above paper was written, the New York Board of Trade and Transportation has taken up the subject of a Naval Reserve, with commendable vigor. It urges the passage by Congress of the Whitthorne bill, and has appointed a committee to examine the subject with a view to State action. Expressions of opinion were solicited from different sources, and the committee has adopted a bill presented by the Navy Department, and will attempt to secure its passage by the State legislature. The articles of this bill are drawn to accord with the Military Code of the State of New York and the provisions of the Whitthorne bill. They provide for the enrollment of a Naval Militia, and for the organization of three battalions of Naval Reserve Artillery and one battalion of the Naval Reserve Torpedo Corps.

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

SHEATHED OR UNSHEATHED SHIPS?

By Naval Constructor Philip Hichborn, U. S. N.

The reconstruction of the United States Navy, begun in 1882, has been liberally provided for during the present Administration, and by the end of the year 1892, or ten years after the good work commenced, there will be a new fleet of thirty vessels of all classes. This respectable nucleus is composed of armor-clads, cruisers, gunboats, etc., as follows:

ARMOR-CLADS.*

Names.	Tons.	Guns.	Speed.
Puritan,	6060	4	13
Miantonomoh,	3815	4	10.5
Amphitrite,	3815	4	12
Terror,	3815	4	12
Monadnock,	3815	4	12
Texas,	6300	10	17
Maine,	6648	10	17
Cruiser (not named),	7500	...	...

Total, eight, of an aggregate cost of $17,012,936.

CRUISERS.

Chicago,	4500	12	14
Boston,	3189	8	14
Atlanta,	3189	8	16.33
Charleston,	3730	8	18
Baltimore,	4413	12	19
Newark,	4083	12	18
Philadelphia,	4324	12	19
San Francisco,	4083	12	19
Cruiser (not named),	5300	...	20
Two cruisers (not named),	3000	...	19

Total, eleven, of an aggregate cost of $14,281,804.

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* Coast-defense monitor not included.

GUNBOATS.

Names.	Tons.	Guns.	Speed.
Yorktown,	1700	6	16
Petrel,	890	4	13
Concord,	1700	6	16
Bennington,	1700	6	16
Three gunboats (not named),	2000	...	...

Total, seven, of an aggregate cost of $3,902,000.

OTHER VESSELS.

Dolphin,	1485	1	15.5
Vesuvius,	725	3	20
Training-ship,	800	...	...
Torpedo-boat,	100	...	22

Total, four, of an average cost of $1,160,000.

RECAPITULATION.

Armor-clads,	8	at a cost of	$17,012,936
Cruisers,	11	" "	14,281,804
Gunboats,	7	" "	3,902,000
Other vessels,	4	" "	1,160,000
Total,	30		$36,356,740

When ready for sea, with armament, etc., the total cost of these thirty vessels will exceed $40,000,000.

The entire fleet is built of steel, with the exception of the five monitors, the hulls of which are of iron.

Leaving out the monitors and the Chicago, Boston, and Atlanta, it will be observed that extraordinary speeds are anticipated in the other vessels; none are to have less than sixteen knots, and the torpedo-boat is even to run twenty-two knots. It is claimed that vessels of similar descriptions built abroad have attained the speed set opposite each vessel in the foregoing table, but it must be borne in mind that it was under the most favorable circumstances, as a rule—with a picked engine-room force and the very best coal—that such speeds were kept up for a few hours. It is also more than probable that the prototypes abroad were running on a light load-line.

As regards the speed of the ships of our new Navy, only four, the Chicago, Boston, Atlanta, and Dolphin, have had a six hours' trial trip at sea, laden to the depth at which they would be submerged when in fighting trim; and there is good reason to believe that their sea speed, under ordinary conditions, will be that placed against their names. For the ships now in course of construction, sixteen, seventeen, eighteen, nineteen, and twenty knots are the speeds to be developed at the trial trips, which will be reduced to an average sea speed of one, two, and three knots less than is claimed for them upon the measured mile trials. Such speeds as fifteen, sixteen, and seventeen knots at sea are a vast improvement upon those of the ships we now possess, none of which exceed twelve knots; and it is to be hoped that the new Navy will not fall short of the great swiftness and general efficiency claimed for it.

The ships are designed of such dimensions, with lines of such fineness, and with machinery of such power, as should ensure a fulfillment of the calculated speed; and the construction of the hulls are of such material and strength as to enable the vessels to withstand the enormous strain of high speeds for many years. Yet the fact has been lost sight of, or been ignored, that an iron or steel bottom begins to foul as soon as placed in salt water, and therefore increases its resistance so as to reduce materially its initial speed. There are but two methods by which this difficulty may be overcome: one, sheathing the ship with wood and then coppering it; the other, by the ever increasing expense of frequent docking and painting.

In order to comprehend clearly the importance of the proposition, "Whether or no, metal bottoms should be sheathed," it is necessary that the results which past experiments have given us should be clearly stated. That the non-professional reader may also understand the subject, a brief résumé of the history of sheathing may be required. Primarily, it should be stated that it is not claimed that all vessels should be sheathed, but only those denominated as cruisers.

The custom of sheathing vessels, which has been supposed by many persons to rank among the modern inventions, is certainly of very ancient date, for it is very nearly coeval with Christianity itself. The authenticity of this is fully proved by the discovery and rescue of Trajan's galley (A. D. 101–117) from the lake Riccio, where it had remained under water for more than thirteen hundred years. Leo Baptiste Alberte, who records the circumstance, states, on his own inspection and knowledge, that the pine and cypress of which it was built had endured, and was then in so sound a state as to be nearly incredible. The bottom was, according to the modern and easily comprehended term, doubled; the seams had evidently been calked with linen, and the whole of the external part carefully smeared or payed with a coat of Greek pitch, over which was secured an exterior covering, or what is now called a sheathing, formed of lead rolled or beaten to a proper thickness, and closely attached to the bottom by a sufficient number of small copper nails.

Lead sheathing was used exclusively up to the year 1761, when the frigate Alarm of the British Navy was sheathed with copper and sent to the West Indies, where she remained for a considerable time. This experiment demonstrated that copper was the best protection against fouling, but it was discovered that the fastening of the plank, which in those days was of iron, had been badly damaged through oxidation. As a result, there was the same talk of economy (by persons whose positions and experience would warrant different opinions and actions) that we hear to-day, and for twenty-two years after the fact had been established that copper was the only preventive against sea-worms and fouling, these wiseacres, although they admitted that copper fastening would have to be substituted for iron bolts and spikes, objected to the change on the plea of economy, and squandered many hundred thousands of pounds on foolish experiments. Throughout this period, copper sheathing was applied to all of the ships of the English Navy, and the injury to the fastenings of the bottoms became so alarming, that, in 1783, the Navy Board seriously contemplated the discontinuance of copper sheathing of vessels "laid up."

The master-shipwrights and other professional officers of the dockyards gave it as their opinion that the use of mixed metal bolts as fastening below the water-line would remedy the evil complained of. The suggestion was adopted and with good results; a still further improvement resulted when copper was substituted, a few months later. The estimated increase in the cost of a first-rate was about $11,000 for substituting copper for iron fastening; and when it is taken in consideration that the total cost of such a ship approximated $500,000, the insignificant additional cost is not worthy of mention.

The first country to take the initiative step in building iron vessels for the Navy was Great Britain. The Dover, a small paddle-steamer, was built in 1839, and was followed by the Alert, Soudan, and Wilberforce, all of small size. It was not until the year 1843, however, that the building of war steamers of iron began; the first, the Trident, of 850 tons, was built by Ditchburn and Moore. During the next three years 34 iron steamers were built by or purchased for the Government, among which were the Birkenhead and Megaera; the latter was lost in 1871 through circumstances that are likely to occur again to any iron steamer, namely, corrosion of skin plates to such an extent that they almost dropped from the frames. France followed England closely in the new departure in shipbuilding, and both countries soon possessed a large number of iron steamers.

But soon a temporary reaction took place, caused by the discovery of the tendency of iron ships to foul. In fact, such was the alarm felt by the Admiralty in 1847 at the formidable character of this kind of mischief, that it threatened to fix a limit to the employment of iron ships for naval purposes. The board had commenced selling, and were debating about the sale of all sea-going *iron* ships. The discovery of an anti-fouling paint that gave very fair results caused the Admiralty to reconsider its contemplated action; the iron vessels were retained and the building of that class continued.

Since 1836, when the first experiments were made to prevent the fouling of the bottoms of metal ships, up to the present time, thousands of patents have been taken out for paints and other appliances having the above object in view, our Government alone having expended over $10,000 in the last six years' tests; but none have come up to the requirements. For the protection of iron, nothing has been found superior to a coating of red lead and white zinc, but no paint has yet been discovered that will prevent fouling for any considerable time. Few subjects connected with the construction of iron and steel ships are more deserving of better attention than the prevention of this fouling and destructive corrosion of unsheathed ships.

The efficiency and durability of hard cold-rolled copper sheathing is admitted to be far superior to either Muntz metal or zinc, the relative values of which may be given approximately at 15, 10, and 5 years respectively. Copper is used almost exclusively for naval vessels, and only in very isolated cases is zinc used.

The difference in friction between a smooth coppered bottom and a smooth painted iron skin is important, and is considered by every naval architect when designing a vessel. The coefficients of resistance for various surfaces are as follows:

Surface.	Coefficient.	Surface.	Coefficient.
Clean copper,	.007	Smooth sawn plank,	.016
Smooth paint,	.010	Moderately foul,	.019
Iron skin,	.014	Barnacled,	.055

The resistance of an iron skin is twice that of a smooth copper bottom, increasing to nearly threefold when moderately foul, and to nearly nine times when barnacled. The latter term, however, is somewhat vague, as the barnacles, seaweed, etc., may have collected upon the iron bottom to such an extent as to reduce the speed of the vessel to an almost imperceptible motion. W. H. White, Chief Constructor of the British Navy, states in his work entitled "Manual of Naval Architecture," page 438, as follows: "A third deduction (in experiments on surface friction) is the great increase which results from a very slight difference in the apparent roughness of the surface. For instance, the frictional resistance of the surface of unbleached calico—not a very rough surface—was shown to be about double that of a varnished surface. This varnished surface, it is interesting to note, gave results just equal to a surface coated with smooth paint, tallow, or composition such as are commonly used on the bottom of iron ships. The frictional resistance of such a surface moving at a speed of 600 feet per minute would be about one-quarter of a pound per square foot of immersed surface for clean bottoms of iron ships when moving at a speed of about 12.8 knots. This unit is worth noting."

Again, on page 448, Mr. White states: "Frictional resistance is the most important element of the total resistance of most ships, and in well-formed ships moving at moderate speed, it constitutes nearly the whole of the resistance. This fact has been established experimentally, but was predicted on theoretical grounds. The experiments made by Mr. Froude in Her Majesty's ship Greyhound, and those made by him on numerous models, show that for speed of from six to eight knots, or about half speed of ordinary ships, the frictional resistance with clean bottoms is 80 or 90 per cent of the total resistance; and at full speed, even of the swiftest ships, the frictional resistance equals 50 or 60 per cent of the total resistance. When the bottom becomes foul, and the coefficients are doubled or trebled in consequence, frictional resistance, of course, assumes a still more important place, the practical effect of which is, as already remarked, a great loss of speed, or a considerably greater expenditure of power in reaching a certain speed."

The trial trips of the Boston and Atlanta furnish striking examples of the serious disadvantages of a foul bottom. These ships are duplicates in every detail, and were loaded to the same draught at their trials. The Atlanta ran a six hours' trial trip on April 13, 1887, and attained an average speed of 15.5 knots, with 3345 indicated horse-power. The Boston had a similar trial on September 1, and made an average of 13.8 knots on 3780 indicated horse-power. The difference in speed and horse-power was therefore as follows:

	Speed.	Horse-Power.
Atlanta,	15.5	3345
Boston,	13.8	3780
Difference,	1.7	435

In other words, although the Boston's engines developed 435 H. P. more than the Atlanta, yet her speed was 1.7 knots less. This discrepancy in speed was solely owing to a foul bottom, as the Boston had been lying in the Wallabout at the Brooklyn yard for over a year. The Atlanta made her trial with a clean bottom, having recently come out of dock with a new coat of paint.

The *Army and Navy Journal* of September 10 contained the following remarks concerning the Atlanta, which still further emphasize the necessity of frequently docking metal bottoms: "It appears that the new cruiser Atlanta mnst be docked, and that speedily, or be numbered among the lame ducks of the Navy. It is said that from not seasonably docking her, thus allowing the bottom to get foul from more than six months' service without inspection, as well as from a break in the propeller while aground for half an hour last summer near Newport, the speed of this fine ship has become much impaired, so that with fifty revolutions of the engines it is but little more than eight knots."

There are only two iron vessels in the old Navy that may be classed as cruisers, the Alert and the Ranger, and both are in the Pacific. They are sister ships of 1020 tons displacement. The Alert is cruising in the Pacific, the Ranger is surveying on the coast of Lower California. Their maximum speed with a clean bottom is about 10 knots. Chief Constructor Wilson, of the U. S. Navy, in his argument for sheathing, submitted a letter from Commander Philip, of the Ranger, under date of June 22, 1882, in which he called attention to the fact that with a clean bottom the ship readily made seven to eight knots on seven tons of coal, while with a foul bottom she made less than six knots, though burning from twelve to fourteen tons a day.

Under date of September 12, 1887, Commander J. D. Graham, of the U. S. S. Alert, wrote to the Navy Department as follows:

"The ship was docked at Callao the latter part of June last, it being about six months from the time she was docked at Mare Island before going into commission. The bottom was very foul, it being estimated that 12 tons of barnacles were taken off. To dock this ship, it cost for the four days we were in dock, $2782 American money. A few days since, the chain to the anchor by which the ship was riding parted, and in order to recover the anchor I was compelled to use the service of a diver. I directed him that while he was down to look at the bottom of the ship, and he reported it as becoming considerably coated again. The bottom fouls very quickly and diminishes the speed greatly. Running from this port (Paita, Peru) to Callao, going down, before docking, we used 80 tons of coal, obtained here at $20 (gold) per ton, amounting to $1600. If the bottom had been clean we would have used only 25 or 30 tons for the trip, making a saving of $1000."

The Ranger was docked at Mare Island last October, about four months after her return from the coast of Lower California. Coming up the harbor to the Navy Yard she is said to have presented a remarkable spectacle. Along the ship's side at the water-line was a thick growth of bright green sea-grass, from a few inches to a foot in length, while kelp in stringers and in bunches up to six feet in length trailed alongside and astern. The water in the Mare Island straits is nearly fresh, and in a few weeks the kelp dropped from the bottom of the vessel; but when docked there was still a large quantity of barnacles, some as deep as one and one-half inches, and a thick growth of marine vegetation with clusters of mussels to an average depth of four inches. Taking at random an area of sixteen square feet, and scraping off and weighing this marine vegetation, barnacles, and mussels, on the day succeeding the docking, the total weight of the entire surface of this stuff was computed at 12 tons, a weight sufficient to increase the draught of the ship nearly one inch. What this incumbrance cost the vessel in speed and coal may be seen from the appended tables of the relative speed and consumption of coal with a clean and a foul bottom:

CLEAN BOTTOM.		FOUL BOTTOM.	
Speed per hour.	Coal, lbs. per hour.	Speed per hour.	Coal, lbs. per hour.
6.	400	6.	850
6.6	630	6.7	1200
8.1	900	8.2	1980
10 2	1250	10.	3240

The Ranger, it should be stated, left the Mare Island Navy Yard in November, 1886, a couple of days after having been docked, cleaned, and painted, and returned during the first week of July, 1887, in the condition described. The above is certainly no record from which the advocates of unsheathed bottoms can derive any satisfaction.

Again, Rear-Admiral S. B. Luce, in a letter to the Navy Department, on May 5, 1887, writes as follows: "The subject of sheathing iron ships has recently been brought to my attention by the experience of the Italian man-of-war Flavio Gioja, which we lately fell in with. She had not been able to find a dry-dock for 19 months, and was so foul that her speed was reduced about one-half. Drawing about 23 feet of water, she could not enter the floating dock at St. Thomas, and was obliged to go to Fort of Franco, Martinique, where there is a very fine dock."

Captain Boyd states that when he commanded the Alert in China, the vessel's speed on one occasion was reduced from 10 to 6 knots per hour; that the vessel was placed in dry-dock at Hong-Kong, and, by actual measurement, 13 tons of barnacles, coral, and vegetable marine growth were removed from the ship's bottom, a considerable amount of iron scale being taken off in the process of removal. On leaving the dock, her speed came up to its normal rate, 10 knots under steam, and 13 knots under canvas.

The action of salt water upon steel rapidly corrodes the metal, and produces what is generally known as "pitting." From the following data, conclusive evidence is shown of its deteriorating effect upon "unsheathed ships."

The U. S. S. Boston, before launching on December 4, 1884, received three coats of paint, composed of two-thirds red lead and one-third white zinc, and on September 10, 1886, while in dock, the bottom was again painted with a coat of "West's Anti-Corrosive Paint." On July 30, 1888, the ship was again placed in dock, and after the bottom was thoroughly scraped to remove barnacles and grass, there remained no sign of the patent paint; but the red lead still adhered to about one quarter of the surface. There was a considerable amount of "pitting" on the bottom plates, extending to a depth of one-sixteenth of an inch, and the edges of the plating were corroded, as were also a number of rivet-heads; these formed the worst cases of "pitting," the holes having a depth of about one-eighth of an inch in some places.

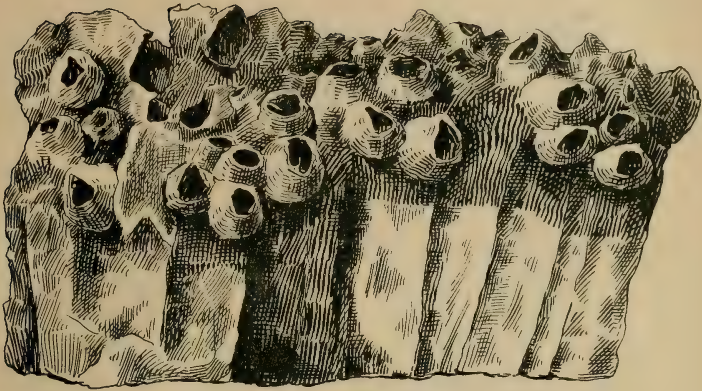
The condition of the Dolphin is also somewhat serious; at about the usual load water-line a "pitted" belt, varying from three to eighteen inches in width, extends from the forward to the after tower. The holes are from one-sixteenth to three-sixteenths of an inch in depth, and as the plates are but seven-sixteenths of an inch in thickness, this becomes quite a serious matter. The efficiency of the ship was also reduced by a very foul bottom, contracted on her recent voyage along the Mexican and South American coasts, where the action of the water upon steel is much more vicious than elsewhere. The loss of speed was nearly two knots per hour, thereby limiting her safe coal endurance to only 2500 miles in very favorable weather, and in rough water to only 2000 miles.

The Esmeralda, of the Chilian Navy, is an example of the attention necessarily given to unsheathed ships required to remain or cruise in tropical seas. She is docked every four months, and four coats of paint are applied at each docking. Among the merchant steamers trading in warm waters, that receive the same treatment, may be mentioned those of the P. S. Nav. Co., the P. S. S. Co., and the Pacific Mail Steamship Co.

On the following pages are full size illustrations of barnacles of only four months' growth that were taken from the bottom of the Pacific Mail Steamer City of Panama, which plies between Panama and Acapulco.

The Senate Committee on Naval Affairs held several meetings during January, 1884, at which the views of Secretary Chandler, Admiral Porter, Chief Constructor Wilson, the members of the Advisory Board, Chief Engineer Isherwood, and a number of other officers of the Navy, were stated in relation to the cruisers Chicago, Boston, and Atlanta, and the dispatch-boat Dolphin, then in course of construction. The subject of "sheathing" was incidentally discussed, in the course of which some very remarkable statements and arguments were made by the opponents to "sheathing." Those who favored the system of sheathing were Chief Constructor Wilson, Chief Engineer Isherwood, Rear-Admiral C. R. P. Rodgers, Senator McPherson; and, according to the statement of the Chief Constructor, "the first Advisory Board, consisting of nine line officers, three engineers, and three naval constructors, had agreed to the fact that it was advisable to sheath over the ships with wood and copper them." There were other officers who opposed the system of sheathing.

The President of the Advisory Board No. 2, Rear-Admiral



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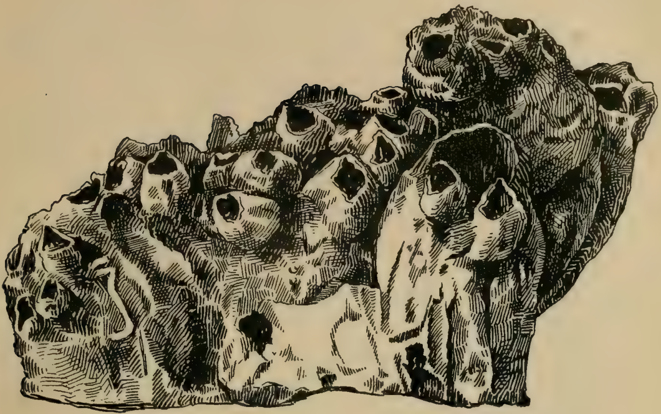

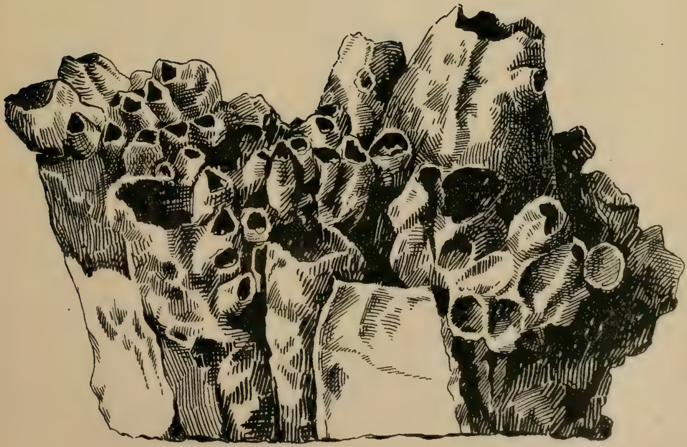

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Shufeldt, read before the Senate Naval Committee referred to, a letter from the Board of December 20, 1882, of which the matter relating to the subject of sheathing read as follows :

" The principal object in sheathing large iron ships is to avoid loss of speed by fouling of the bottom, by the use of copper sheathing. This desirable result is only imperfectly secured, and the only additional advantage is that the local strength of the bottom is increased. To use copper sheathing without injury to the ship's iron bottom, owing to the galvanic action set up in sea-water, it is necessary that the two should be completely insulated. This involves the use of brass stern and stem posts, and that the iron or steel bottoms be cased in two thicknesses of wood, the inner one being bolted to the skin with iron screw bolts, and the outer fastened to the inner with brass screws, as shown in the above cross-section. It can be readily seen that this system requires skillful workmanship and the utmost care to perfect insulation.

The Board decided not to sheath the ships, on the following grounds :

" 1. It did not add to the durability, as with even ordinary care the lifetime of an iron ship is practically unknown.

2. The weight of hull is from 12 to 15 per cent increased, and, regarding the displacement as a fixed quantity, the efficiency of a given ship is correspondingly reduced.

3. Taking into consideration the great first cost of sheathing, the fact that now that there are large docks in all parts of the world, the steel bottom can be kept as clean as a copper one by judicious selection of paint and docking twice or three times per year, without greater annual expenditure.

4. The use of a double bottom provides the same safety obtained by the greater local strength of the sheathed bottom."

The Admiral makes the point in favor of sheathing, that it increases the local strength of the bottom, but claims again that " the use of a double bottom provides the same safety obtained by the greater local strength of the sheathed bottom."

In the Baltimore and in the Charleston, now in course of construction, the transverse frames in wake of the double bottom are spaced 4 feet apart, and the longitudinals are about 7 feet apart. Making due allowance for the angles to which the skin plating is riveted, there is an area of about 24 square feet over which the skin or outer bottom plating, one-half inch in thickness, is laid. This unsupported surface will naturally have a tendency to buckle, and the wood sheathing would entirely prevent such an occurrence. The inner bottom or ceiling plating upon the frames is to prevent the water that may come through the outer bottom when the ship is leaking, from getting over the floors and thus eventually sinking the vessel. The inner bottom does, of course, add to the strength of the ship, but its primary object is to confine the water within certain safe limits, and it is not likely to prevent buckling of the outboard skin plating. A sheathed vessel would, in addition, take the ground more easily, and the structure proper of the ship would be subjected to less damage than if the ship settled upon a surface of 24 square feet of one-half inch steel plate.

There are three systems of shipbuilding, in so far as relates to the material employed—wood, metal, and composite. The last named is that in which metal and wood are both used. In the British Navy, shipbuilding in wood has practically ceased since 1874, and composite vessels of considerable size and speed have been built as a compromise between iron and wood hulls.

The composite ship, with its keel, stem, stern-post of wood, and its frames and beams of iron or steel, or both, and with an outer planking, has the elements of strength of the metal ship to a large extent, and also the advantages of a copper-sheathed bottom. These ships are especially fitted for cruising purposes, as they do not need to go into dock to be cleaned and painted, as is the case with metal ships.

The prejudice that once, and not so very long ago, existed against metal ships has entirely disappeared, and it is admitted that for durability and strength the steel ship cannot be surpassed. Therefore, when such a scientific and practical naval construction corps as the French still continue to build wooden vessels, the reason must be that the advantage of the strength of the metal ship is weighed against the advantage of continued speed of the wooden vessel, and that speed, which means efficiency under all circumstances and safety in some cases, has influenced the construction policy of the French. Quite a number of French armor-clads, built for service abroad, are built of wood, and some upon the composite system.

The sheathed ship possesses all the advantages of the steel or iron ship and of the wooden vessel. It has the strength and durability of the metal ship without any of the drawbacks incidental to an iron or steel bottom, as its submerged surface is coppered, and therefore rarely requires docking for the purpose of cleaning.

As to the criticism directed at those who advocate sheathing, by saying that no holes should be bored in the bottom of any ship, it rather indicates an excess of feeling in behalf of their side of the question. The "holes bored in the bottom" would be those through which the screw-bolts for the inner layer of planking would be put, and taking 80 three-quarter inch bolts as the number through a plate 4 feet wide and 12 feet long, the total diameters of the bolts would reduce the width of the plate to 42 inches, but the margin of safety would be such as to make this apparent loss quite imperceptible to the skin plating of a ship.

The statement of Chief Constructor E. J. Reed, of the British Navy, in his report to the Committee on Designs of Ships of War, in 1871, was as follows: "I would also like to take the opportunity of saying that I think, in combining an iron frame, or, in fact, an iron built vessel with wood and copper, as in the Inconstant, we are making a very great experiment, but one forced upon us, because it would be absurd to build a wooden ship to go that speed and expect her to take the strain of her engines, and it would be equally absurd to build an iron ship to go that speed which would foul, as the fouling would take off from that extreme speed. We have no alternative, therefore, except to adopt some such system of construction as that of the Inconstant."

It should be stated, in this connection, that up to the time at which Sir E. J. Reed made the above statement, the armor-clads Audacious, Swiftsure, Triumph, and Vixen had been sheathed with wood; and of unarmored cruisers, the Inconstant, Active, and Volage were built in a similar manner; and further, that they have been in active service upon foreign stations almost continuously up to the present time, and bid fair to continue as useful vessels for many years to come.

As will be seen from the subjoined table of sheathed vessels, this mode of protecting a ship's bottom and preventing fouling is not an experiment, and has been quite extensively adopted.

SHEATHED NAVAL VESSELS.

Country and Name of Ship.	Class.	Tons.	Built.
Argentine Republic.			
Almirante Brown, ...	Armor-clad,	4200	1880
Patagonia, ...	Cruiser,	1500	1885

Country and Name of Ship.	Class.	Tons.	Built.
Brazil.			
Aquidaban,	Armor-clad,	5000	1885
Riachuelo,	"	5700	1883
(Not named),	"	5000	Building.
"	Cruiser,	3960	
Guarany,	Gunboat,	250	1883
Iniciadora,	"	268	1883
Marajo,	"	410	1885
(Not named) two,	Monitor,		Building.
" twelve,	Gunboat,		"
" one,	Cruiser,	3960	"
Purus,	Transport,	1355	1874
Chili.			
Blanco Encalada,	Armor-clad,	3500	1875
France.			
Duguay Trouin,	Corvette,	3140	1877
Duquesne,	Frigate,	5440	1876
Sfax,	Cruiser,	4420	1884
Tourville,	Frigate,	5440	1876
Germany.			
Leipzig,	Frigate,	3860	1875
Prinz Adalbert,	"	3860	1876
Bismarck,	"	2810	1877
Stein,	"	2810	1879
Stosch,	"	2810	1877
Gneisenau,	"	2810	1879
Moltke,	"	2810	1877
Elisabeth (in place of),	Cruiser,	4250	Building.
Alexandrine,	Corvette,	2335	1885
Arcona,	"	2335	1885
Carola,	"	2130	1880
Marie,	"	2130	1881
Olga,	"	2130	1880
Sophie,	"	2130	1881
Habicht,	Gunboat,	835	1879
Mowe,	"	835	1879
Charlotte,	Frigate,	3310	1885
Blucher,	Torpedo-ship,	2810	1877
Nixe,	Frigate,	1725	1885
Greece.			
Admiral Miaulis,	Corvette,	1770	1879
Hydra,	Gunboat,	480	1881
Spetsais,	"	480	1881

Country and Name of Ship.	Class.	Tons.	Built.
Great Britain.			
Audacious,	Armor-clad,	6010	1869
Impérieuse,	"	7390	1883
Nelson,	"	7630	1876
Neptune,	"	9310	1874
Northampton,	"	7630	1875
Shannon,	"	5390	1875
Swiftsure,	"	6910	1870
Temeraire,	"	8540	1876
Triumph,	"	6640	1870
Vixen,	"	1230	1865
Warspite,	"	7390	1884
Active,	Corvette,	3080	1869
Bacchante,	"	4130	1876
Boadicea,	"	4140	1875
Calliope,	"	2770	1884
Calypso,	"	2770	1883
Canada,	"	2380	1881
Carysfort,	"	2380	1878
Champion,	"	2380	1878
Cleopatra,	"	2380	1878
Comus,	"	2380	1878
Constance,	"	2380	1878
Conquest,	"	2380	1878
Cordelia,	"	2380	1880
Curaçoa,	"	2380	1881
Euryalus,	"	4140	1877
Inconstant,	Frigate,	5780	1868
Raleigh,	"	5200	1873
Rover,	Corvette,	3460	1874
Shah,	Frigate,	6250	1873
Volage,	Corvette,	3080	1869
Magicienne,	Cruiser,	2950	Building.
Marathon,	"	2950	"
Holland.			
Atjeh,	Cruiser,	3430	1876
De Ruyter,	"	3430	1880
Johan Willem Friso,	"	3430	Building.
Koningin Emma,	"	3430	1879
Tromp,	"	3430	1877
Van Speyk,	"	3430	1882
Bonaire,	"	840	1877
Sommelsdijk,	"	950	1882
Suriname,	"	840	1877
Bali,	"	840	1878

Country and Name of Ship.	Class.	Tons.	Built.
Holland.—*Continued.*			
Batavia,	Cruiser.	840	1876
Benkoelen,	"	840	1874
Java,	"	1100	1885
Macassar,	"	840	1876
Madura,	"	840	1880
Padang,	"	840	1878
Samarang,	"	840	1876
Bromo,	Pdl. Cruiser,	1530	1874
Merapi,	"	1530	1874
Italy.			
Italia,	Armor-clad,	13,680	1880
Palestro,	"	6180	1871
Principe Amedeo,	"	5880	1872
Venezia,	Torpedo-ship,	5720	1869
Japan.			
Fu-Sô,	Armor-clad,	3718	1877
Mexico.			
Independencia,	Gunboat,	600	1874
Libertad,	"	600	1874
Russia.			
Alexander II.,	Armor-clad,	8440	Building.
Peter Veliky,	"	8750	1872
Dmitri-Donskoï,	"	5800	1883
Vladimir-Monomach,	"	5800	1882
General-Admiral,	"	4600	1873
Herzog-Edinburgski,	"	4600	1875
Novgorod,	"	2700	1873
Vice-Admiral Popoff,	"	3590	1875
Catherina II.,	"	10,150	Building.
Sinope,	"	10,150	"
Tchesma,	"	10,150	"
Nicholas I.,	"	8440	"
Rynda,	Cruiser,	2950	1884
Vitiaz,	"	2950	1885
(Not named),	"	4300	Building.
Vsriw,	Torpedo-ship,	135	1877
Dzigit,	Clipper,	1460	1876
Kreiser,	"	1540	1875
Razboinik,	"	1330	1878
Strelok,	"	1840	1879
(Not named),	Armor-clad,	8000	Building.
Sweden.			
Freja,	Corvette,	2000	1885

Country and Name of Ship.	Class.	Tons.	Built.
Portugal.			
Alfonso de Albuquerque,	Corvette,	1110	1884
Rio Lima,	Gunboat,	610	1875
Bengo,	"	420	1879
Mandovi,	"	420	1879
Liberal,	"	447	1884
Zaire,	"	447	1884

Of the 142 armor-clads of France, England, Italy, Russia, and Germany, built since 1870, there are 26 sheathed with planking over an iron skin; 12 are built of wood, 6 are composite, and the remainder are built of iron or steel, or both entirely.

Of the unarmored vessels composing the effective fleets of the above named naval powers, there are 337. These vessels may be classified as follows: 118 with hulls of iron, steel, or both entire; 109 of composite build; 56 are entirely wood hulls, and 54 are of iron or steel hulls sheathed with wood.

That sheathing can be successfully applied to a metal ship while in the course of construction is demonstrated by the fact that such a large number of that class, built from 1865 to the present time, are still in existence, and have served in extended and repeated commissions. The additional expense incurred in putting on the sheathing of wood and copper is in reality a great saving during the lifetime of the ship, as it obviates the necessity of frequent docking and the largely increased coal bills while the metal bottom is foul.

The copper sheathing was removed from the Ajax of the British Navy in 1845, said sheathing having been on the ship for sixteen years, and it was found that it had lost only one-thirtieth part of its weight in that time, through exfoliation.

The Shah (also of the British Navy), which is a sheathed vessel, was refitted in 1878; the sheathing was then nearly twelve years old, and the examination of the hull showed it to be still sound in all parts.

Another example of a successfully sheathed iron ship is the French cruiser Duquesne. According to the *Mémorial Génie Maritime*, the object of building this ship with wooden sheathing was to "insure its ability to maintain the high speed of seventeen knots," and she has not disappointed her designer. The ship was docked in November last, ostensibly for the purpose of cleaning the bottom. The vegetation upon the bottom was practically nothing; it was easily removed, and its total weight was less than half a ton. Yet this ship had not been docked for *four* years, and the past thirty months she had been in the Pacific. The hull was apparently as sound as could be expected from a vessel eleven years old, and with the original boilers in her, she could still maintain a speed of sixteen knots.

Upon the examination of the Blanco Encalada in 1885, the hull was found to be in excellent condition, and the fear entertained that the wood planking would rot under a ship's bottom had not been realized in this vessel, although it had been in service more than ten years. There is something remarkable about the good condition of the zinc sheathing of the Encalada; and it is owing to one of two circumstances, either that the zinc was of an unusually excellent quality, or that the ship had not lain in waters which would have destroyed either iron or copper in less than a couple of years. No evidence of any injury to the iron plating, which was examined in many places, could be detected. The experiment of zinc sheathing upon a single layer of wood was thus found to have been more successful than could have been hoped for.

It will thus be seen that, while in some few cases zinc sheathing has proved advantageous, yet copper sheathing is to be preferred, and can be applied to an iron or steel bottom; but to insure the most perfect insulation, a double layer of planking should be fitted; the first, or that next to the iron plating, should be secured by iron bolts; the second, fastened to this by copper bolts and then sheathed with the best cold-rolled copper. The first cost is, of course, considerable, but its beneficial and truly economical results far outweigh the increased first cost of a sheathed ship over that of an unprotected metal bottom.

It is the general opinion of the best authorities in England that all steel cruisers should be wood-sheathed and then coppered.

There have been cases where both copper and zinc sheathing have been destroyed in less than a year, as in the case of the U. S. S. Brooklyn and the U. S. S. Thetis, both of which are wooden vessels. The copper sheathing of the Brooklyn was almost totally destroyed while on the South American station in 1882; but such exceedingly rare events are due to some want of attention in the melting and refining process of the copper, or to the fact that the ship has lain for months in close proximity to the outlet of city sewers. The zinc sheathing of the Thetis, which is a wooden vessel, was applied just before leaving for the Pacific. When docked at the Mare Island Navy Yard, about seven months later, the zinc was found to have nearly disappeared from the bottom of the ship; here and there were a few patches, worn down to the thickness of ordinary writing paper, its aggregate weight being only 2300 pounds, or about 20 per cent of the total weight put on the vessel seven months before.

The Independencia is the only instance, as far as the writer has been able to ascertain, where sheathing was apparently not a success. But there were mitigating circumstances connected with this exceptional case. In Brassey's work, "The British Navy," a history of the ship is given, from which it is learned that the Independencia was designed in 1872 for the Brazilian Government, by Sir E. Reed, and built by Messrs. J. & W. Dudgeon, of Millwall.

In the operation of launching, the Neptune (as the ship was afterwards named) met with an accident. She stopped at the end of the ways, with her after-part overhanging. She was gotten off and docked at Woolwich; but the work of restoration proved to be of very formidable character. The repairs were carried out by the Messrs. Samuda Bros., under the direction of Sir Edward Reed. The repairs cost nearly $500,000 and bankrupted the builders, and in 1878 the ship was purchased by the British Government for $3,000,000, and changes and repairs were proceeded with. It was not until February, 1883, that the ship was docked preparatory to going into commission, when, as might have been expected, the bottom was found to be in a bad condition, and, through imperfect fitting of the sheathing, as claimed, it was found that galvanic action was taking place by which the iron bottom was being eaten away. The *London Chronicle*, in reporting this bad state of affairs, says: "Nor is this all, for, having settled down on the blocks, the false keel, the wood of which is in good condition, has been 'hogged' by the weight of the superincumbent mass, and it is probable that the keel-plates have in parts been seriously weakened."

This latter statement explains the whole situation. The ship, badly strained when launched, never afterwards became as staunch as such a structure should be. It is evident that when an iron ship gets hogged, the bottom is strained, and no matter how carefully the sheathing is put on, the weakness of the ship proper cannot be remedied by putting on sheathing; but the latter may keep water out to a considerable extent and thus be the means of keeping the ship afloat.

It should be noted that, notwithstanding the bad condition of the ship, the Neptune was nevertheless sent to sea and has remained in commission ever since.

It is scarcely worth the space to give extended quotations from the opponents to the sheathing plan. The opposition came chiefly from persons who admitted that they were not experts, and whose prejudice—for such is the proper term for unreasoning opposition—was based upon the extra cost entailed and the assumed difficulty of properly sheathing and coppering a metal bottom.

The gentlemen opposed to sheathing proved that they had given the subject very little thought. They ignored the chief objection to sheathing, namely, "the danger of bad workmanship, by which a galvanic action takes place between the iron skin and the copper sheathing, resulting in the destruction of the iron." Their chief concern was that the wood under the bottom would rot. Shipbuilders and other experts entertain the old fogy notion that the wood bottom will outwear three top-sides of a ship, and that a vessel with wood bottom and iron top-sides would be practically indestructible, assuming, of course, that the ship would not take the ground, but always be where there was a sufficiency of water under the keel.

They also presumed to characterize as "absurd" a fact that has been theoretically and practically demonstrated, that a copper-sheathed bottom will require less power to drive it than an iron bottom painted, even though the former carries the additional weight of sheathing.

It should be taken in consideration, however, that it is the opinion of a lawyer, against the scientific researches of such men as Rankine, Froude, and a score of other scientific and thoroughly practical experts. They argued that "the multiplication of dockyards all over the world, and the absolute certainty that if we became a naval power we must provide ourselves with docking facilities," is a sufficient objection to sheathing iron ships. But in this argument (?) they gave away their case completely.

Ships-of-war are maintained for defensive and offensive purposes primarily. In peace times they are practically of no value, except so far as to "show the flag" in foreign ports and to be a school for our officers and crew. A national ship is a welcome visitor in every port, and at a dockyard all courtesies are extended and facilities offered. The officers are dined and wined, and the ship, if in need of repairs to her bottom, is taken in dock and attended to. As soon, however, as war breaks out, there is of necessity a cessation of all such amicable relations between naval authorities. Ships are then fitted out for the purpose of protecting the country's coast, to sail in fleets to engage in battle with foreign fleets, or to hunt up and capture unarmed merchant vessels, or, if necessary, to have a brush with some naval vessel belonging to the enemy. Vessels in the latter service are denominated cruisers, and it is of such that our new Navy is chiefly composed.

The opponents to sheathing allude to "the multiplicity of dockyards all over the world," but apparently forget that such are not for the use of our ships in the event of war. As Chief Engineer Isherwood states, "we have no colonies where in war our cruisers might be docked, and neutral powers would not allow their docks to be so used." Our naval vessels would therefore have to depend entirely upon the docking facilities at home, which in the case of the 16-, 17-, 18-, and 19-knot cruisers would mean that they could remain out only so long as their fuel held out and their bottoms remained clean; then they would have to return for coaling and cleaning, a proceeding that would have to be repeated every three or four months. Having little or no sail power, these cruisers would be limited as to distance, as the coal supply would be exhausted in less than one month at the moderate speed of 10 knots per hour, during which interval the cruiser would have to cover her distance out from an American port and return.

The Confederate cruisers Alabama and Shenandoah were coppered ships, and the former during her almost continuous cruise from July 29, 1862 until June 11, 1864, or nearly two years, was not once placed in dock. Had these vessels been of iron with unprotected bottoms, their career of usefulness as commerce-destroyers would have been greatly abbreviated, and instead of inflicting a damage to our merchant marine of about $13,000,000, the depredations of these two ships would have probably amounted to only one-tenth of that sum.

It may be of interest to the general reader to know the extent of the "multiplicity of dockyards" and private docks all over the world. It will, with the aid of a Mercator's Atlas, be easy to show how few and far between are the facilities for docking upon the ocean highways, where vessels of the United States Navy, especially cruisers, could go in to scrape and paint bottoms. It would, of course, be useless for this country to send its ships-of-war into European waters, where they would be picked up by overwhelming numbers of the enemy's ships, if the war was with either England or France.

The hostile operations would therefore be limited to within a few hundred miles of our own coast upon the Atlantic and the Pacific, and to an occasional brief cruise to the West Indies, while the paint upon the cruiser's bottom was still fresh. On the Atlantic coast the Government docks are limited to Portsmouth, N. H., one floating dock; New York, one stone dock, and a timber dock now building; and at Norfolk, one stone dock, and a timber dock (building). Of the projected docks, no account has been taken in the following tabulated statement:

DISTRIBUTION OF THE DRY-DOCKS OF THE WORLD.

Austria, ...	5	Portugal, ...	4
Belgium, ...	11	Russia, ...	7
Denmark, ...	4	Spain, ...	13
France, ...	53	Sweden, ...	13
Germany, ...	31	Turkey, ...	4
Great Britain, . . .	265	Africa, ...	6
Greece, ...	1	America, ...	88
Holland, ...	17	Asia, ...	60
Italy, ...	13	Australasia, ...	12
Norway, ...	9		

Making a total of 615 docks in the world.

Of the 166 docks in Africa, America, and Australia, 87 are owned by the governments or citizens of European countries, as follows:

Country.	Africa.	America.	Asia.	Australia.	Total.
France, . .	3	1	1	1	6
Great Britain,	2	15	51	10	78
Holland, . .				1	1
Portugal, . .	1				1
Spain, . . .		1			1
Total,	6	17	52	12	87

Thus revised, the number of docks owned at home and abroad by the different countries are:

Nations.	At home.	Abroad.	Total.
Austria, ...	5	...	5
Belgium, ...	11	...	11
Denmark, ...	4	...	4
France, ...	53	6	59
Germany, ...	31	...	31

Nations.	At home.	Abroad.	Total.
Great Britain,	265	78	343
Greece,	1	...	1
Holland,	17	1	18
Italy,	13	...	13
Norway,	9	...	9
Portugal,	4	1	5
Russia,	7	...	7
Spain,	13	1	14
Sweden,	13	...	13
Turkey,	4	...	4
United States,	60	...	60
Peru,	1	...	1
Chili,	2	...	2
Argentine Republic,	4	...	4
Brazil,	4	...	4
China,	3	...	3
Japan,	5	...	5
Total,	529	87	616

From the foregoing table it appears that Great Britain controls or owns nearly 56 per cent of all the dockyards in the world. It has 10 in Australia, 15 in China, 36 in India and the adjacent islands. It owns 2 in Africa, 12 in Canada and British Columbia, 2 in the West Indies, 3 at Malta, and 1 at Demerara, N. G. The other 262 docks are within the confines of England, Scotland, and Ireland. In this connection it may also be of interest to recapitulate the number of Government dockyards owned by each country, namely:

Austria,	2	Portugal,	1
Belgium,	2	Russia,	7
Denmark,	2	Spain,	7
France,	32	Sweden,	6
Germany,	8	Turkey,	4
Great Britain,	42	United States,	6
Greece,	1	Peru,	1
Holland,	2	Chili,	2
Italy,	8	Brazil,	2
Norway,	3	China,	3
Japan,	2		
		Total,	143

Let the reader follow the course taken by a cruiser from the Brooklyn yard, bound for the Pacific to protect American shipping or to chase and capture the enemy's vessels. The rendezvous of this cruiser would naturally be the Mare Island Navy Yard, so often referred to in each report of the Secretary of the Navy. Here the cruiser would call in to be docked for cleaning and painting, something quite necessary after a voyage of 15,000 miles. The cruiser would, of course, stop at Rio Janeiro to coal, and perhaps to dock, there being three docks of sufficient size to accommodate a ship of from 3000 to 5000 tons displacement. At Montevideo, 1200 miles farther south, or 7300 miles from New York, there are docking facilities for vessels not drawing over 18 feet. But after this there is no opportunity to dock until San Francisco is reached, for all the docks on the west coast of South America, at Valparaiso and Callao, three in number, range only from 1500 to 2500 tons lifting capacity.

It might happen that every dock at Rio or at Montevideo were in use at the very time that our cruiser desired to be accommodated, and the voyage might thereby be extended through the enforced delay. Even in time of war, if there was a disposition not to enforce the neutrality laws, and a Government dry-dock was opened for an American cruiser, history might repeat the incident at the Brooklyn yard in November, 1873, where, while the Spanish ironclad Arapiles was in dock, the barge Upland, laden with coal, unfortunately sprang aleak and sank directly in front of the gate to the dock. At any other time this event would have caused no comment, but as the Virginius affair was in course of dispute between the United States and Spain, there were many hints that the accident was an attempt to keep a powerful ironclad a prisoner. This accident may happen to one of our ships, and the Brazilians might remember how a United States ship captured the privateer Florida in the harbor of Bahia on October 7, 1864.

Once safe on the coast of California, the cruiser would have the choice of only two localities for docking to scrape and paint her bottom, namely, at San Francisco (or Mare Island), and Portland, 800 miles farther north, the latter within close proximity to the British naval establishment at Esquimault, Victoria, B. C. The docking facilities at Mare Island consist of one stone dry-dock, large enough to accommodate any war vessel except the large Italian armor-clads and those of England. Another dock at Mare Island, built of timber, has been in use since 1853 and is rapidly decaying. The docks at

San Francisco are the dry-docks at Hunter's Point, of a nearly similar capacity to that at Mare Island, and the hydraulic dock of the Union Iron Works, capable of lifting a vessel of about 3000 tons displacement.

In Government docks the sole expense is that of the labor to prepare the dock and take the ship in and out. For a vessel like the Chicago, the cost would be between $300 and $400 for docking alone. To this sum must be added about $1000 for scraping and painting, making a total of about $1400. The actual cost of docking and painting the Atlanta is $1250.

It is something quite different when a private dock is engaged. In Great Britain, great competition has brought the charges down to a minimum, but the docks in India, China, Australia, and on the Pacific Coast are very expensive. A few years ago, at San Francisco, the docking of the French ironclad Triumphante cost about $15,000 for five days, and when another French ship, the Duquesne, required docking in November last, the private dock wanted $5000 for the first day and $2500 for each additional "lay-day." It would therefore appear that docking is an expensive operation, at least in the waters to which our ships-of-war would be confined in war time, and, moreover, that sometimes it might not be had at any cost, except at a few home ports.

It is advocated that by docking ships every four to six months the bottoms could be kept in good condition for steaming. Here is an admission that a steel bottom requires docking and painting two or three times annually to keep it in good condition for steaming; to cover this expense it is proposed to devote the interest money, say $4500, or the cost of sheathing a vessel of the Chicago's size, plus the saving in not having to keep the wood and copper sheathing in repair. As will be shown further on, the docking of a metal bottom is absolutely necessary at least three times annually, in order that the ship may retain a moderate speed without an excessive expenditure of fuel. As the new cruisers, however, are to have sea-speeds ranging from 15 to 18 knots, it will not be unreasonable to average their docking at four times a year.

Now, unless our cruisers are all to go to Europe, where docking is cheap, or remain upon the Atlantic coast, within easy reach of a navy-yard dock, it will be found that there will be a very large deficit in their dockage fund. To dock the Chicago in any port in India, Australia, China, Japan, or at San Francisco would involve for docking alone an expense each time of not less than $10,000; and the labor of cleaning (not by "blue jackets"), together with painting, would approximate $2000. Here is a yearly expenditure of over $30,000 for docking, cleaning, and painting an unsheathed bottom, amounting during a cruise of three years to nearly $100,000.

In this connection another fact not generally considered is the risk of having the ship damaged through careless docking. Merchant vessels as a rule enter the dock without cargoes, while ships-of-war discharge only their powder; the difficulty and risk is therefore greater in docking the latter. The hogging of a cruiser or the starting of rivets through careless docking is likely to occur. In the first instance the shaft may be thrown out of line, thus destroying the machinery; in the latter case, leaks may be caused, through the starting of rivets, and the vessel will have to go into dock again.

It is often observed that "the wood sheathing has to be applied with great care to insure perfect insulation of all steel work," all of which is admitted; but the capital of which $32,000 annually is the interest expended upon one steel bottom for docking, would apply the sheathing to several cruisers. One other statement often made deserves to be corrected: "other nations speaking of sheathing, when seeking high speed, have omitted it."

It is only necessary to refer the reader to the speed of some of the sheathed ships built abroad, in order to expose this disregard of facts that are accessible to all.

SPEED OF UNARMORED CRUISERS (SHEATHED).

Name of Ship.	Country.	Speed in knots.
Inconstant,	England,	16.5
Shah,	"	16.6
Raleigh,	"	15.5
Volage,	"	15.0
Active,	"	15.0
Bacchante,	"	15.0
Boadicea,	"	14.8
Euryalus,	"	14.7
Rover,	"	14.5
Duquesne,	France,	15.9
Tourville,	"	16.9
Duguay,	"	15.0

The above speeds are in some instances rather high, and what is still more to the point, the sheathed vessel of 16.5 knots speed will maintain a greater average speed throughout the year than either the Iris or Mercury of 18.5 knots speed, notwithstanding the occasional dockings of the latter unsheathed ships.

There is another aspect of the sheathing question that is sure to present itself very soon to our naval authorities and to Congress. It is this : that as all of our new cruisers are in a measure dependent upon steam for their locomotion, the coal bills will henceforth become one of the chief items in the naval appropriation bills. From July 1, 1880 to July 1, 1887 our naval vessels consumed about 327,500 tons of coal at an aggregate cost of nearly $2,500,000, which gives an average of 46,775 tons at a cost of $357,143 annually. Every cruising ship in the present Navy is provided with sail power, and the General Order of 1887, enjoining the strictest economy in the use of coal, and prescribing that " it shall not be used except under the most urgent circumstances," is still in force. The modern cruiser has no sail power, and as a consequence every ship of that kind added to the Navy means an increased expense for fuel. It will probably be no exaggeration to claim that the coal supply will have to be doubled, at least, over that now used, when the modern cruiser shall have supplanted the present class of ships.

From the records of five cruising vessels, the distance covered during their respective period of commission was as follows :

Name of Ship.	Period.	No. of Miles.
Essex,	3 years,	55,000
Brooklyn,	3 "	38,773
Vandalia,	2 "	26,230
Pensacola,	10 months,	26,785
Enterprise,	20 "	17,300

The average distance run per month by these five vessels was 1450 miles ; and, assuming that any of the new cruisers, say the Baltimore, made a similar record during a three years' cruise, the distance covered would be 52,000 miles. The most economical speed of such a vessel would probably be 10 knots, upon a consumption of 25 tons of coal. The quantity of coal used would therefore be 5416 tons, which, at $4.50 per ton upon the Atlantic side, would amount to $24,372 ; but on the Pacific coast, where coal averages about $15 per ton, the coal bill for a three years' cruise would amount to $81,240.

As it is not to be supposed that this fast cruiser would always jog along at the easy gait of 10 knots, but that at times she would run on three quarters or full speed, and that on account of the foul condition of her bottom the consumption of coal would be largely increased over 25 tons per day, a fifty per cent increase in coal consumption might not be too wide of the mark, and the coal bills upon the Atlantic and the Pacific would be $32,622 and $122,332 respectively. If to this latter is added $100,000 for dockage, cleaning, and painting during her three years' commission, it will be seen that a modern steel cruiser, without sail and without sheathing, is a very expensive ship, much greater than the Congressmen who cast their votes for such ships have any idea of.

The opponents to the sheathing of cruisers appear to have labored in the direction only of establishing a peace Navy, or to have had it in their mind that the new ships should always be within reach of a dock. This, as has been shown, would be practically no Navy at all. The nineteen-knot cruiser would speedily be reduced to fifteen and even less, and in that condition would be unable to overhaul a fast merchant vessel, nor could she run away from an enemy of greater speed and heavier metal.

The most striking illustration of the importance of speed at the right time is furnished by the memorable naval fight in which the Peruvian ironclad Huascar was captured by the Chilians. Referring to "War Series No. 2," entitled, "The War on the Pacific Coast of South America," etc., issued by the Office of Intelligence, Navy Department, on page 40, the report of Lieutenant T. B. M. Mason, U. S. N., states:

"The Huascar had been sent south with the Union on her fourth raid by order of General Prado, and against the advice of Admiral Grau. The latter asserted that his ship's bottom was exceedingly foul, and that her speed had been impaired by long active service. He urged that he should be allowed to go to Callao, where the only means of repairs existed, as he considered his vessel of too great a value, in the present reduced state of speed, to be needlessly risked. Other counsels prevailed, however, and Peru's only hope started south September 30, 1879, with her brave commander, the latter never to return, the former to add to the already superior strength of the enemy.

The combat between the Chilian squadron, consisting of the ironclads Almirante Cochrane and Blanco Encalada, the corvette

O'Higgins, the gunboat Covadonga, and the transports Loa and Mathias Cousino, and the Peruvian Huascar, turret-ship, and the corvette Union, took place October 8, 1879, off Mejillones, Bolivia. The Cochrane and Blanco were ironclads of 3560 tons displacement. The latter had a sheathed bottom covered with zinc, but was very foul, while the Cochrane's iron skin was in good condition, as it had recently been cleaned, and the ship was capable of steaming 11 knots. The Huascar, on the other hand, was only 1130 tons displacement, and not having been docked since June, or a little over three months before, her speed was somewhat reduced through the foulness of her bottom, and Admiral Grau had the best of reasons for not courting a fight with an overwhelming force."

Continuing fragmentary extracts from the reports, we find on page 42: "At about 7.15 smoke was seen from the Huascar on the horizon to the northwest, and at 7.30, she having stood slightly westward to reconnoitre, the Cochrane and her consorts were recognized. The Huascar was seen at about the same time from the Cochrane's top, and the Loa was sent to reconnoitre. Admiral Grau, who had now come on deck, probably felt confident that he could elude the Cochrane, as her speed, according to the latest information in his possession, was only eight knots, and stood for a short time towards the Loa. Finding, however, that the Cochrane was changing her bearings more rapidly than he had anticipated, he stood more to the westward and ordered full speed. The three ironclads were now about eight thousand yards distant from each other. Grau saw that his only chance of escape lay in his speed. At 9.10, as the Cochrane had approached to within less than four thousand yards, and it was evident that she could cross his bows, he ordered the crew to quarters, and shortly afterwards entered his conning tower alone. There was but a small difference in the speed of the Huascar and her two opponents, but the difference—not as great as half a knot—virtually decided the combat."

It has already been observed that the Blanco Encalada was sheathed with wood and zinc. She was built in 1874, and was not docked and cleaned until August 19, 1885, when taken to England for refitting. It is not at all surprising that a zinc bottom should become foul during a continuous service of eleven years on the South American coast.

The most elaborate and conclusive protest against the use of metal bottoms without sheathing and coppering was offered by Chief Engineer Isherwood. The Senate Committee on Naval Affairs directed Mr. Isherwood, on February 5th, to examine the testimony taken by the committee in relation to the new cruisers, then in course of construction; and on the 11th, or six days later, Mr. Isherwood submitted his findings and criticisms on said testimony, of which so much as relates to the sheathing of vessels is quoted as follows:

"*The Cruiser Chicago.*—The hull is to be painted only, and to have no other protection from the corrosion and the fouling which inevitably take place with iron exposed to the sea-water. Paint is an insufficient protector; the water penetrates it, and more efficient means must be employed. The fouling is a vastly more serious evil than the corroding, and there is but one means known for securing the vessel from both, namely, sheathing her with wood and coppering the sheathing. This system, properly executed, secures the hull absolutely from external corrosion and from the fouling due to accretion of barnacles, marine grass, etc.

Fouling of Iron Bottoms.—From the moment that any known substance is put into sea-water the fouling commences; the barnacles, oysters, sea grass, etc., begin at once to accumulate upon its surfaces, and with about equal rapidity for all substances. All kinds of paint, thus far tried, fail in prevention, though some retard the evil more than others, but it comes to all; the difference is only in time and is not very great. Under otherwise equal conditions the fouling is more rapid as the sea-water is warmer. In the North Atlantic, where the water is much cooler than within the tropics, the fouling is comparatively slow; but in the latter it proceeds with wonderful rapidity, a few degrees increase of temperature making a strongly marked increase.

The transatlantic iron steamships plying between New York and the ports of Northern Europe find a great difference in their fouling whether they follow the northern or the southern route.

Advantages of Copper Sheathing.—There has just been said that the accretions of fauna and flora take place in sea-water upon the surfaces of all substances with about equal rapidity. This of course includes copper, but that metal being easily corrodible in sea-water, and the resulting verdigris being excessively pulverulent and having scarcely any adhesion to its metallic base, falls off with the application of the least force, like the wash of the waves or the movement of the vessel through the water, and in falling off carries with it the marine accretions, leaving the metal continually bright and clean. So continuous is the corrosion of the copper and the falling off of the verdigris that the spores of the marine fauna and flora have no time to develope, and the copper continues clean indefinitely.

There have been a few cases in which a coppered bottom has become foul when the vessel lay a long time in still and warm water, but as soon as she was under way the barnacles and grass were rapidly swept off.

The particular kind of brass called Muntz metal is frequently employed as a substitute for copper in sheathing ships, owing to its greater cheapness, but it is inferior for that purpose to the pure metal, and will sometimes show fouling to a small extent.

Paint is No Protection.—As regards iron, the product of its corrosion in sea-water, the hydrated carbonate of the peroxide of iron, adheres strongly to its metallic base and never falls off. It can only be removed, and with difficulty, by steel scrapers and chisels, and whatever marine animals attach themselves to it remain and grow, and receive continual accretions on top of them, of others, which remain and grow also, until the mass, if not mechanically removed, soon increases to inches in thickness, while the marine grass waves over it half a yard in length, and the sea-moss thickly fills the interstices.

Exactly the same result happens to the painted iron surface as long as the paint remains, and it remains a long time when protected by the covering of marine animals and plants described. The most successful paints are those in which the copper corrosive effects are feebly imitated by composing them of materials that will gradually become pulverulent and fall off. The success thus far in that direction is but little, and the bottoms of all iron ships, be they painted with what they may, commence to foul as soon as they are in sea-water, and continue to foul as long as they remain in it.

Loss of Speed by Fouling.—The effect of the fouling is to enormously increase the resistance of the vessel to the water and to decrease her speed accordingly. The principal resistance of vessels is that which is due to their immersed or wetted surfaces; it is least with perfectly smooth surfaces, and increases with increasing roughness. When in excess, the speed of the vessel may be reduced one-third for an exposure of a few months in tropical sea-water. The writer has taken large oysters from the bottom of an iron vessel after a few months cruising in the Gulf of Mexico.

The Westphalia is an iron transatlantic steamer plying between New York and Hamburg, in the comparatively cool water of the North Atlantic. She makes two round voyages in three months, during which time her bottom is exposed to the sea-water about fifty-five days. At the end of each round voyage she lies in fresh water of the river Elbe, on entering which the marine life attached to the bottom dies at once and drops off. Notwithstanding this, she is docked at the end of each two round voyages and the bottom scraped and freshly painted with the best anti-fouling paint known.

The average speed of the Westphalia is 11 knots per hour, and the difference of speed just before cleaning and just afterwards, with the same development of power, is one knot per hour in favor of the latter, as has been accurately ascertained, showing an increase in the resistance of the vessel of 25 per cent, due to the fouling under these favorable conditions of cleanliness.

What Foul Bottoms Cost in Speed.—As a general result, the resistance of a well painted iron bottom will average, for an exposure of three months to sea-water, an increase of fifty per cent, involving a loss of about one-seventh of the speed. For example, a vessel that makes 14 knots per hour with clean bottom will average only 12 knots during the three months.

If at the commencement of the three months the resistance be taken as one, then at the end of the three months it will be represented by two, and the loss of speed at the end of the three months will be about one-fourth; that is to say, the 14 knots will have fallen to 10 knots.

The only method known whereby this disastrous loss of speed can be prevented is to sheath the bottom of the iron vessel to a certain height above water with wood, and to copper the sheathing; and this method must be adopted for naval cruisers, let its cost or disadvantages be what they may.

Wasteful Economy.—Can there be a greater folly than to construct an enormously expensive iron naval cruiser for high speed, sacrificing almost all the other qualities of the vessel to that end, and then to deliberately throw away this dear-bought advantage for absolutely nothing? Because, in the construction of such a vessel, the additional expense of the wooden sheathing and of the copper need not be considered, as it has not been considered in any other respect.

If expense were a factor in the design of such a vessel, it should have been built of puddled iron instead of ingot iron, which costs 50 per cent more per pound.

In fact, for sheathed and unsheathed vessels of the same form and dimensions, fitted with machinery to give them the equal speed during prolonged cruising at sea, and supplied with coal for steaming equal distances at that speed, it is probable that the sheathed vessel will be less costly and have more available internal space than the unsheathed vessel.

Sheathing More Economical.—Again, supposing two iron hulls of the same form and dimensions, fitted with machinery and carrying the same quantity of coal, and then let one of them be sheathed.

The draught of water of the sheathed vessel will remain the same as before, or rather will be a little less, because the additional displacement made by the sheathing will be somewhat greater than the weight of the sheathing. In this case, the immersed or wetted surface of the sheathed vessel will be slightly greater than that of the unsheathed vessel, and its greatest immersed transverse section will be a little larger by the cross-section of the sheathing; but the average resistance of the vessel at sea will be so enormously lessened by the substitution of the copper surface for that of the painted iron, that in comparison of it, the two small causes of increase in the resistance cited vanish utterly.

The internal space will be the same in both vessels, but the sheathed one will have a very much greater average speed, or, for equality of speed and endurance, can have very much less machinery and coal.

Sheathing Favored by Experts.—Considered from any point of view, the superiority, and in a very high degree, is the vessel, and it is difficult to understand how any other conclusion could be reached by any person comprehending the problem. Every great naval architect and every marine engineer of reputation, without exception, have the views herein stated. And the adoption of sheathing for our iron cruisers was at once unanimously voted as a matter not needing discussion by the first Naval Advisory Board, as appears in the unpublished minutes of their proceedings.

The idea can scarcely be seriously entertained by any person that a naval cruiser can be put in a dry-dock and the bottom cleaned every few months. She must be able to go for years without docking, and in the warm sea-water of the tropics; and if she cannot do that, her usefulness will be limited indeed. We have no colonies where in war our cruisers might be docked, and neutral powers would not allow their docks to be so used.

If the condition of usefulness of these vessels is that they must be docked every few months, they would not be able, in time of war, to go far from our own ports. Even in peace the opportunities for docking are few and far between, and the necessity for it may come when the services of the vessel are pressingly needed and time cannot be afforded. The condition of the captain of a national cruiser on a foreign station, when ordered instantly on important duty which required the utmost celerity, would be pitiable indeed, if, with a foul-bottomed vessel and greatly reduced speed, he had first to seek some port that had a dry-dock, beg permission for its use, and wait there until his vessel was cleaned before he could obey his orders. The delay might be fatal.

Cruisers of Slow Speed.—The omission of sheathing on these vessels is ruinous to their value. It destroys their speed, increases their consumption of fuel, restricts their range of cruising, and limits the services they might otherwise render. Something they could doubtless do; but for the purposes they should be built, namely, that of extremely fast cruisers of long endurance, having ability to keep the sea with unimpaired powers under all circumstances, to be able to destroy the commerce of a foe, to be safe from his pursuit in their great speed, and to be able to overtake and capture everything of inferior force, they will be egregious failures.

The great mistake of not sheathing those vessels is irretrievable failures. No more should be constructed in that manner.

Sufficient data and arguments have probably been presented in the foregoing to show how speedily the efficiency of an iron or steel bottom is destroyed through fouling; but the opinions of experts, or at least unprejudiced opinions of reputable journals upon this most important subject, deserve to be incorporated in this article."

The *Nautical Gazette* of New York, conducted by an experienced nautical man, has this to say under date of April 6: "Sample barnacles four inches long have been received at the Navy Department, which were taken from the bottom of the Pacific Mail Steamship City of Para, after four months' exposure. Referring to the first Advisory Board, we find that sheathed vessels were recommended as a protection against barnacles and other fouling; the last 'Board on Additional Cruisers' recommended Gunboat No. 2 to be composite, for the same reason. Neither of these recommendations were adopted, and the result is that the Navy is now building thirteen ships of naked iron or steel. A war-vessel cannot make a port at regular intervals as a merchant ship does, but is called upon to keep the sea for extended periods. Great Britain has possessions scattered over the whole temperate and tropical surface of the earth, with harbors, coaling stations and dry-docks. We have many thousand miles of coast, and but few harbors deep enough to accommodate the new Navy, with no outlying possessions, and but few dry-docks. With these facts staring us in the face, the Department should have looked to it that the new ships were protected."

The *Army and Navy Journal* had the following editorial on August 16, 1887: "After an enforced idleness of something like nine months, the Atlanta was recently docked for the purpose of cleaning her bottom of the accumulations of barnacles and other marine growths, animal and vegetable, which had increased to such an extent as to interfere seriously with her speed and handiness. And this brings to notice a fact which seems to have escaped the comment of all critics of the new steel cruisers, *i. e.*, the constant fouling to which steel and iron bottoms are liable in all parts of the world, but particularly in tropical waters. A ship of the class of which the Atlanta is a type should be taken from the water at least twice a year for the purpose of cleaning and painting. Without this, such a vessel soon loses speed; and as the marine growths increase all the faster as attention is delayed, very speedily degenerates into a slow hulk, scarcely able to get out of her own way. But a semi-annual docking means a semi-annual expense of no small moment in the case of a ship of say 6000 tons, and indeed there is more than one station included in our naval cruising grounds where a vessel of that tonnage cannot be docked at all. So that the United States may find itself in the near future possessed of not one, but several white elephants, in the shape of steel cruisers which must be docked if they are to be kept in a condition to deserve their name, and which cannot be docked for want of the proper facilities, our Government not having the docks required, and those in foreign ports being either too small or otherwise occupied. A vessel of 6000 tons on the South Pacific station cannot be taken out of the water at any point nearer than San Francisco, which requires a voyage of such length that its cost precludes its being undertaken with the frequency called for by a steel or iron vessel whose bottom is unprotected by a sheathing of wood and copper.

Attention is called to this, not in the spirit of captious criticism, but as a matter of the utmost importance to the Navy at this time, when it appears that the tide of favor toward it is setting strongly in the direction of liberal appropriations for ships and armor. Certainly the question of sheathed cruisers, composite-built ships, and otherwise protected bottoms, is one worthy of the most careful inquiry and examination by the able corps of designers and constructors upon which the country will rely with full confidence for the evolution of a Navy worthy of the renown attained in the days of Hull, Stewart, Farragut, and Porter. Let not, then, a few theorists commit us to a single line of policy in the construction, but let us learn from the costly experience of others and avoid the mistake of 'putting all of our eggs in one basket.'"

It has been the endeavor in the foregoing article to present some of the data and arguments for and against the sheathing policy, and it is to be hoped that our naval authorities and our legislators in Congress will give the subject the attention that it merits. The false economy of leaving the bottom of a steel vessel unprotected is a very serious matter, as it impairs the usefulness of the ship in times of peace, and virtually renders it incapable of its intended purposes in the event of war.

U. S. NAVAL WAR COLLEGE,
NEWPORT, R. I., *November* 27, 1888.

To the Secretary of the Naval Institute.

SIR:—On several occasions there has been urged upon me the wish that the text of the lectures given at the Naval War College should be published; and the opinion has been expressed that, by using the pages of the Naval Institute as a vehicle for such publication, a much larger audience would be reached than can be expected to assemble from year to year at the College. I have therefore thought it well to commit to writing the general considerations which have indisposed me to adopt such policy as a rule, however willing to accede to occasional exceptions.

Assuming, for the sake of argument, that the material accumulated in the lectures is valuable, and that the general line of thought to which they have been devoted is, as I think, one far too little worked in the Navy, it follows of course that the greater the number whose attention and interest can be attracted, the greater the benefit of the College to the service. But does it also follow that that attention and interest will be most widely and strongly secured by publication in any form? To maintain this position, it must be assumed that the large majority of officers are students, that they have the leisure and the will to inform themselves, that they do not yield to the delusive feeling that they can "read that" at any time, and so indefinitely postpone their reading. All know that objects of interest which strangers from afar make great efforts to visit, are neglected and often never even seen by those born and living near by.

Sea-officers of our Navy are divided under two leading heads: those at sea and those on shore duty. It is proverbial that the sea life is not favorable to habits of study, and each passing year now adds its share to the burden of miscellaneous duties by which time is there occupied. On shore duty, many of us remember a time when there was too much of leisure, but it is rarely so now. The manifold advance of the day, the introduction of more active, systematic and ambitious effort, have made shore duty anything but a place for loungers.

It follows that the majority of officers, if they will extend their interest beyond the duties with which they are immediately charged, must do so at the expense of their hours of recreation. They must not only give up enjoyment, but must in many cases bring to the new pursuit minds already jaded and attentions wearied by work in itself sufficient for the day's ordinary stint. Yet if the outside professional interest is worth their attention at all, it is worthy of their best powers.

I suppose we have all admitted to ourselves by this time that we can no longer hope to be abreast of the advance in *all* matters of professional interest. The complex development of the present day has reconciled us to specialties, and to being ourselves non-specialists in some, perhaps in many, of the necessary factors that make up a modern war-ship. If there be, however, any one branch in which we should have clear views, a wide and deep knowledge, not only of the truths, but of the reasons and arguments by which those truths are established, it is the conduct of war, or art of war, the systematic development and exposition of which is the object of the War College, and the reason for its existence.

I have already drawn attention, in a paper which has been published in the Proceedings of the Institute,* to the fact that the naval officer, sympathizing therein with the tendency of the age, is interesting himself far more in the development of material than in the art of fighting, which is nevertheless his proper business. It is therefore unnecessary now to say about this evident truth more than this: that if the instruction of the War College is printed in the Proceedings on an equal footing, as of course it must be, with the mass of matter dealing with all sorts of mechanical and physical problems, it will be swamped by them—it will receive rare and desultory attention. It is now thought, practically, more important for a naval officer to know how to build a gun, to design a ship, to understand the strength of materials, to observe the stars through a telescope, to be wise in chemistry and electricity, than to have ingrained in him the knowledge of the laws of war, to understand the tactical handling of his weapons, to be expert in questions of naval policy, strategy, and tactics. This is, I think, all wrong; but it can be set right, not by printing our work, however good it be, among a lot of papers on matters considered more important, but only by an *organized effort of the Government* to create and disseminate a system of naval war. The College is such an organized attempt.

*Vol. XIV., No. 4.

Such being a skeleton of the arguments against printing, what are the advantages conceived to belong to the College system of lectures; to which is hoped to be added, when we are permitted, a quiet existence without daily fear of death, carefully directed investigation and discussion, both in and out of the lecture-room?

At its annual session the College receives a number of officers, the greater part of whom, probably, are not students, nor would, if left to themselves, initiate any independent study of the principles and art of war. They have orders to listen, and they do listen with the readiness of men who are accustomed to obey orders. I am encouraged to believe that in the greater part of what they have so far heard they have found interest and instruction, and the more so that, having no other present duty, they bring to this, at the best part of the day, minds fresh and without pre-occupation. The subjects are treated not in a single paper, but *in extenso*, consecutively and from day to day; in time, kindred subjects will be brought into closer connection, and the whole series invested with an importance which, though justly its due, is not to be attained except by isolating it for awhile from other matters of professional interest.

To all this must be added, that when a lecturer is master of his business, nothing in the way of reading can equal such instruction. The correct emphasis and division of sentences adds much to clearness; the teacher feels when he fails to interest, or when he is obscure, and, either by judicious enlargement or judicious curtailing, remedies on the spot faults which he may not have appreciated in the solitude of his study.

The effect upon those who attend the course, though more widely diffused, is, however, the least part of the benefit of the College. It is a commonplace of education that nothing teaches like the duty of teaching others. To a very large extent the lecturers at the College have begun to study their subject with a view to teaching. They from the first contemplate facing a critical audience of the very high average of our naval officers. They are not to appear, as the essayists of the Institute may, responsible to no one, at liberty to express their opinions and consider them as good as another's. They come, with whatever admissions of imperfection, as men who claim to have some mastery—some right to speak because they have knowledge. What one prints may not have to be debated; but it is unpleasant to stand and talk, knowing of weak places in your armor, and that the eyes about are sharp enough to detect them. All this constitutes a stimulus to do one's best, which is freely felt and acknowledged. When it is realized, as it must be after a moment's thought, that we have no Art of Naval War as yet, it will be admitted that the audience at the War College, by its effect upon the lecturers, must be a potent factor in building up that art.

All these advantages will be sacrificed by free and indiscriminate publication. "Why should I go to the College? I can read that which is taught there." When will he read? When he feels like it. When will he feel like it? Who can tell? When will the lecturer write? When he feels in the mood. What shall take the place of that fixed time and that expectant audience, some of whom at least will see through him if he is a sham? How far is it the habit of the essayists of the Institute to pursue consecutively some line of thought, paper after paper? What stimulus do they find in the thought of eager readers? Do they believe in their existence as a large body?

The College ensures an audience. It ensures the dissemination of such results as the lecturers obtain. It invests the whole with the sanction of superior authority, the weight of which with naval officers is indisputable. If it publish, the incentives are lost; most will be unwilling to make the sacrifices necessary to attend, and it is known that some at least cannot be compelled. The uncertainties of the last year have taught me that when the audience is insecure, the lecturers feel indifference. The result would be a cessation of production; publication would cease because there was nothing to publish, and the College itself would come to an end because it no longer justified its existence. Yet without some such governmental care as is implied by an organized institution, it is vain to hope for the development of the art of naval war.

It is for these reasons, and not from any illiberal wish to monopolize advantages, that the publication of the lectures of the College has, as a rule, been discouraged.

Very respectfully, your obedient servant,

A. T. MAHAN, *Captain, U. S. N.,*
President, War College.

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

NAVAL COAST SIGNALS.

BY LIEUTENANT RICHARD WAINWRIGHT, U. S. N.

The defense of our coast has lately occupied a prominent place in the eyes of the public, if one may judge from the numerous magazine articles, newspaper references, and Congressional reports, showing both action and inaction. That eventually we shall take some means of adequately protecting our coast, no one can doubt; the question that naturally arises in one's mind is, whether proper action will be taken before or after an attempt is made upon our great maritime centers. Whatever may be the method adopted—purely military, purely naval, or a judicious mixture of the two—the conveying of intelligence from one point of the coast to the other will be of the utmost importance. With fortifications, we shall always need stations from which the movements of the enemy and the number and character of the vessels can be reported. And when we have a defending fleet, we shall need, in addition, to be able to convey such information to our fleet as will enable them to meet the enemy and frustrate his designs. Even should we have a Navy commensurate with our wealth and importance among the other great nations, we still should need the assistance of shore observers to enable us to defend properly our great length of coast line.

The English naval manœuvres of August, 1887, plainly illustrate the necessity of properly located signal stations along the coast. In the operations of Squadron "A" in the English Channel, the general idea was that the British cruisers had lost touch of an enemy's fleet that had put to sea with the intention of damaging the English ports in the Channel and in the Thames and Medway, while avoiding, if possible, the British fleet. Lookout stations were organized by Admiral Hewett, commanding the force on the defensive, at the

Lizard, Start, Portland Bill, St. Catherine's, Beachy Head, Dungeness, and the South Foreland; these were always in telegraphic communication with each other and with Portsmouth, Devonport, Portland, and Deal. They were of the greatest service, but the facilities for communicating with the fleet were very imperfect, depending entirely upon the dispatch-boats, and for this purpose Admiral Hewett had only the Mercury, the Rattlesnake, and three torpedo-boats, and these had to be diverted from their legitimate duties as scouts, etc., to convey telegrams. The attacking fleet was first sighted from the Lizard at 1.50 A. M. This news was received by Admiral Hewett, then off Portland, at 6.15 A. M.; at the same time he received a second telegram of 2.20 A. M. He sent in for further news, and received at 10.15 A. M. telegrams from the Lizard of 4.50, 5.15, 6.47, and 8.15 A. M. 42 minutes was the greatest length of time taken for a telegram to reach Portland, but from that station to the Admiral it required from 3h. 33m. to 5h. 25m. When the telegram first arrived, he was 110 miles from Falmouth; as the attacking squadron left there at 1.30 P. M., the defense had only 7 hours to make that distance. Waiting for further information, the defense did not sail until 10.30 A. M., when they proceeded at full speed for Rame Head, 80 miles away. Early intelligence would have enabled the defense to have regained touch of the attacking squadron, and possibly to have saved Falmouth.

In the proceedings of "B" Squadron off the Irish coast, lookout stations were organized by the defending force at six points, but, the attack having been sighted by the fleet of the defense early in the operations, they were little used.*

An ideal system of transmitting intelligence coastwise and to seaward during a naval war would be one in which observation stations, connected by telegraph lines, were established at certain intervals along the coast: at each station, trained men with the necessary instruments for receiving and sending visual signals; at certain of these stations, pigeon-lofts for furnishing pigeons to lookout vessels and receiving from them reports, and also for dispatching birds with information to the outside stations of the fleet; also lofts at such stations as, from the position of the telegraph lines, are liable to have their connections interrupted, the birds being used to maintain communication when the lines are cut. All coast lines to be connected with the interior lines, whenever practicable, in order to give additional security. The instruments necessary are heliographs, electrographs, semaphores, and, at the most important stations, captive balloons. By means of observation vessels also, furnished with signal instruments and pigeons, the point towards which the enemy is making would be known, and his progress along the coast followed by the observers, so that the defending fleet might meet him, or, if acting as a flanking fleet, follow him up and engage him at the critical moment. If the enemy's fleet break up into detachments, the course of each will be known to the admiral commanding the defense, and he can oppose the enemy with similar detachments, or keep his fleet together and overwhelm the smaller bodies with his united force. Thus, at a comparatively small cost, the effective strength of the fleet would be greatly increased, to the greater security of the defense. In times of peace these signal stations could be utilized by the Life Saving Service and Weather Bureau, and for the purpose of sending the usual commercial intelligence. As will be seen, the system adopted by the French approaches very closely the ideal one.

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* Office of Naval Intelligence. General Information Series No. VII.

SIGNAL STATIONS.

England.—The proprietors of the "Shipping Gazette and Lloyds List" have established signal stations with which ships can communicate at ten points, and the committee of Lloyds have also established, or are in the course of establishing, signal stations at twenty other points. The stations, where in operation, are available to shipowners for reporting to them the passing of their vessels, by telegrams despatched direct from the signal stations. Flags and distance signals are used. There are many semaphores established on the French, Italian, and Portuguese coasts, and one has recently been established at the island of Lissa (coast of Austria). A semaphore has also been erected at Santander, Spain. The semaphore or signal stations have, wherever practicable, the means of intercommunication by telegraphic wire, and are connected with the chief metropolitan, provincial, and foreign telegraph stations.*

England has no stations prepared for time of war, but it would not be difficult to organize a system, as the Coast Guard already act as signal-men for the meteorological office, and as a part of the weather bureau system. There are 548 Coast Guard stations on the coasts of England, Scotland, and Ireland.

Canada.—Canada is fairly well provided with means of signaling for commercial purposes. There are 26 electro-signal stations in operation, in accordance with the international code of signals: three on Newfoundland, at Cape Race, Langley or Little Miquelon, and Cape Ray; two on Cape Breton Island, at Low Point and at Cape St. Lawrence; four in the Magdalen Islands; four on Anticosti; four just north of Chaleur Bay, at Point Monquereau, Cape Despair, Cape Rozier, and Fame Point; and nine in the St. Lawrence river, all on the south bank, except one on the Brandy Pots. These are connected by telegraph lines and cables with one another and with Quebec. There are also numerous telegraph stations along the coast, where signal stations might be established.

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* British Code List, 1885.

Italy.—In Italy there are 32 semaphore stations, all but three connected by telegraph lines. These are at Ponza, Tremeti, and Ventotene. There are several semaphore stations on the coasts of Denmark, Portugal, and Spain, and on the coast of France they are numerous.

DAY SIGNALS.

Semaphores, French.—The semaphores are the instruments for visual signaling established at the entrances of ports, upon the islands or the elevated points of the coast, above the buildings called electro-semaphore stations. The object of the semaphores is to place the maritime authorities in communication with the ships of war or merchant marine that pass within sight. For this object, the stations are connected among themselves and with the telegraphic system of the state by short lines. Close by each station is placed a wooden mast rigged with a yard and with horns supplied with halliards, that allow the use of the conventional signals, and the flag signals of the international code. The lookouts can signal to the vessels at sea the orders and information that are sent them by the prefect of the maritime district or the minister. They receive questions from the ships, which they should answer, and information to be transmitted to the maritime authorities. In addition to this they can transmit private telegrams.

The semaphore is a hollow iron mast turning on its heel, carrying a disk and three arms that move in the same plane. The disk placed on the top of the mast should always be perpendicular to the direction of the vessel or communicating semaphore. The disk should be so placed by the lookout that the ship will see it on the right-hand side of the mast. The disk, being thus always on the right, can take several positions that serve to indicate the book in which the signal must be read. The arms, by the various positions in which they are placed, signal the numbers representing the words to be signaled.

There are six signal books given to a semaphore station. 1st. The semaphore signals. 2d. The telegraphic dictionary used by the naval forces. 3d. Geographic vocabulary. 4th. The official numbers of the boats. 5th. Boat tactics. 6th. International code. The semaphore signals are divided into three parts. The disk can take five different positions that indicate in which book or in which part of the semaphore book the numbers are to be found. 1. The disk at rest along the mast, the arms indicating a number, represents the signals in the third part of the semaphore book. 2. Inclined downward at an angle of 45°, the arms indicating a number, it represents the signals in the telegraphic dictionary or geographic vocabulary. 3. Horizontal and alone, it indicates the signal front of the semaphore, or that the station wishes to communicate or that it understands the signal. If the arms indicate a number, it represents the signals in the first part of the semaphore book. 4. Inclined upwards at an angle of 45° and alone, it annuls the signal that follows; if the arms indicate a number, it represents the signals in the second part of the semaphore book. 5. Turned vertically upwards, it represents the distant signals of the international code.*

Semaphore.—English.—The semaphore signals *must always be read off as distance signals*, the position or direction of the arms indicating respectively the *pennant*, the *ball*, or the *flag*. The disk at the top of the semaphore mast remains in the position indicated whilst signals are being made by the code.†

Semaphores for Vessels.—All officers must have encountered the difficulty of making out flag signals at times. If the wind is in the wrong direction, or if there is no wind, or if the haze or smoke prevents the colors from being readily distinguished, flags are very unsatisfactory. This becomes important, not only when communicating with signal stations and in the ordinary manœuvres of the fleet, but also in battle signals. Admiral Freemantle, in his valuable paper on Naval Tactics,‡ says: "A word about signals. Our present flag signals have stood the test of years of evolutions, and have scarcely been changed for the last quarter of a century, but they are inapplicable to action in the present day, for the simple reason that while guns' crews and officers in conning towers are more or less fully protected, the signal-man, his halliards and his flags, are exposed to machine-gun fire. The semaphore has been tried for evolutions, and if the semaphore can be fairly trusted, I would suggest a plated tower for the signal-men, or a portion of the conning tower being kept apart for their use, whence a large semaphore should be worked in action. It has been suggested that the arms of this semaphore should be worked from the top of a 'military mast' in our turret ships, which seems worth a trial."

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* Manuel du Matelot-Timonier.

† British Code List.

‡ Journal of the Royal United Service Institution, Vol. XXX., No. 133.

Lieutenant J. F. Meigs, U. S. N., reports as follows: "The use of semaphores, consisting of two arms, which may be placed at various angles with a vertical post, is much favored in the British Navy. Many ships have now a semaphore on each quarter and on each bow, so that signals may be made clear of the ship's masts; and masthead semaphores, having longer and larger arms, are now fitted to mastless ships. They are operated by a crank and endless chain, the position of the crank corresponding exactly with that of the semaphore arm. The use of two flags, instead of one as is customary in our service, is approved, as being more rapid than the one-flag method. In one or two signals which I saw transmitted, the flags or semaphores were operated very rapidly and apparently without fear of mistake in either sending or reading; but I was, of course, unable to judge of the celerity, as I did not know what message was being transmitted."

Distance Signals.—In 1876, Lieutenant T. B. M. Mason, in a paper entitled "Two Lessons from the Future,"* suggests that as flags are unreliable, we should use solid figures, such as balls, barrels, cones, double cones, and a combination of barrel and cone. These to be made of colored bunting; when not in use to be closed up like Japanese lanterns. We have already a distant signal code, being a combination of square flags, triangular flags (pennants), and balls. The solid figures suggested by Lieutenant Mason are superior, as they present the same surface to all points of the compass, but for distance signals and for battle signals they should be of uniform color. The semaphore will take the place of other day signals at ordinary distances as a method of communicating between vessels and between shore and ship. For battle and distant signaling, the solid figures of uniform color will be used. In addition to these when the smoke

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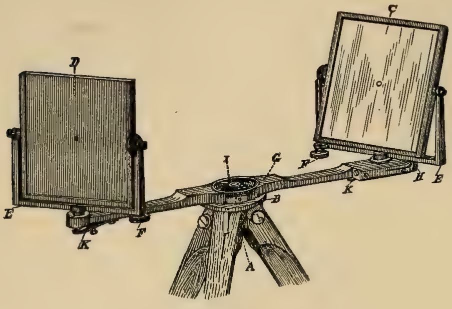
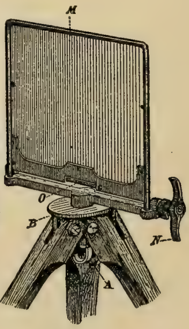
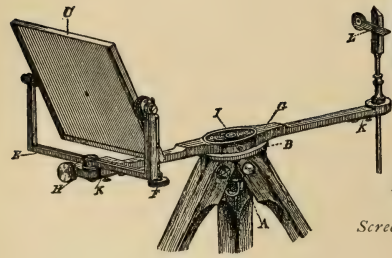
* Proceedings U. S. Naval Institute, Vol. II., p. 65.



Heliograph with two mirrors. Sun in rear.



Screen mounted on tripod.



Heliograph with one mirror and sighting rod. Sun in front.

A Tripod.
B Tripod head.
C Sun mirror.
D Station mirror.
E Mirror supports.
F Tangent screw for revolving mirror about horizontal axis.
G Mirror bar.
H Tangent screw with ball bearings for revolving mirror about vertical axis.
I Clamp screw for attaching mirror bar to tripod.
K Spring for clamping mirrors and sighting rod.
L Sighting rod with movable disk.
M Screen.
N Key for screen.
O Screen spring.

To face page 67.

becomes thick, Japanese day signals will be used. They consist of bombs which when exploded throw out various shapes; they can be thrown sufficiently high to explode well above the smoke, and as the thick smoke in ordinary circumstances does not rise very high, they would be visible from the tops. They would also be used in some cases by lookout vessels and scouts to warn the fleet or shore stations of the approach of the enemy. Shapes should be used to distinguish the vessels of the fleet, and when wrapped in smoke, an occasional bomb thrown up to indicate to the admiral the position of his vessels. It will be very necessary in the heat of battle to be able to distinguish rapidly between friend and foe, and it may add greatly to the completeness of a victory if the admiral, by being able to make out the position of his vessels, can send reinforcements where needed.

Heliograph.—The following description of the heliograph is taken from the Instructions for Use of the Service Heliograph, prepared by First Lieutenant R. E. Thompson, 6th Infantry, and approved by the Chief Signal Officer:

"The *sun mirror* has an unsilvered spot at its center, the *station mirror* a paper disk; in other respects they are similar.

The tangent screw attachment to the frame affords the means of revolving the mirror about a horizontal axis.

The support to the frame has a conical projection accurately turned to fit the socket of the mirror bar, and grooved to receive the clamp spring.

The *screen* of hard vulcanized fiber is provided with a key, by which, in connection with the action of a spiral spring, it is operated to reveal and cut off the flash.

The base of the frame carries a female screw for attachment to the tripod.

The *sighting rod* is fitted to the socket of the mirror bar, and is clamped in the same manner as the mirrors. It carries at one end a movable disk, which, when turned down, reveals the front sight.

A piece of white paper should be slipped into the disk to receive the "shadow spot," and a slight puncture made therein coincident with the point of the front sight as guide in adjustment.

Vertical adjustment of the disk is made possible by loosening the milled slide.

The *mirror bar* is provided with a clamp, threaded to fit the screw of the tripod. The release of the clamp permits movement of the bar independent of the screw.

At one end is attached the tangent screw for revolving mirror about a vertical axis, and it should be observed that under all circumstances the *sun mirror* should be clamped to this end, while the socket at the other extremity is designed to receive the station mirror or the sighting rod.

A movable spring is placed under each end of the bar for clamping mirrors and sighting rod.

The *tripods* are similar, the screw of either serving equally well for the attachment of mirror bar or screen.

Both are provided with a hook for the suspension of a weight to give greater stability when required.

Signaling is effected by depressing the screen for periods of time required to display flashes corresponding to dots and dashes.

The *dot* is represented by a momentary exposition of the flash, and the duration of this exposition constitutes the *unit of time.*

The *dash* is represented by an exposition of the flash for a period of three units of time.

The *pause* between the elements of a letter is equivalent to the unit of time; that between letters, to three such units; and between words, to six units.

In setting up the instrument, spread the tripod legs sufficiently to give a good base, and on yielding soil press firmly into the ground, the head approximately level. In a high wind, ballast by hanging a substantial weight to the hook. If the legs become loose at the head joints, apply the screwdriver to the assembling screws.

See that the screen completely obscures (cuts off) the flash, also that the flash passes entire when key is depressed. The spiral spring should return the screen sharply to its normal position when key is released. If it fails to respond promptly, strengthen or replace.

Extra care bestowed on preliminary adjustment is repaid by increased brilliancy of flash. With alignment absolutely assured and the shadow-spot at the center of the disk, the axis of the cone of reflected rays is coincident with the line of sight, and the distant station receives the greatest possible intensity of light.

The distant operator is necessarily the best judge as to the flash received; if, therefore, adjustment is called when the shadow-spot is at the center of the disk, *alignment* is at fault. Accuracy of alignment may be tested by looking into the sun-mirror, bringing the eye into line with the unsilvered spot, the reflection of disk, and reflection of the distant station. If now the position of the eye be changed, the unsilvered spot and reflected disk will no longer cover, but *the lines of their centers in all positions will intersect at the reflection of the station, if alignment be true.*

The tendency of the shadow-spot to move off the disk, due to the apparent motion of the sun, is compensated for, without interrupting signals, by means of the tangent screws of the sun-mirror. The movement imparted by these screws to the mirror does not disturb alignment, as its center (the unsilvered spot) is at the intersection of the axes of revolution.

It is of the utmost importance that uniformity in mechanical movement of the screen be cultivated, as lack of rhythm in the signals of the sender entails unnecessary and vexatious concentration of attention upon the receiver. The contrast between dots and dashes should be pronounced and unmistakable. For the dot, the flash is almost instantaneous. To avoid continuity of light, release the screen at the moment of depression. For the dash, dwell somewhat on exposure, with a tendency to lengthen rather than shorten the period of duration prescribed.

The manipulation of the instrument involves but slight manual labor ; the strain on the eyes, however, from the flash of the mirrors in receiving, is often considerable, but may be modified by the use of stained glasses. It will also occasionally be found advantageous to screen the eyes from the glare of surrounding objects.

Ability to read signals from the heliograph may be readily acquired, but may also be as readily lost if practice be discontinued before proficiency is attained. It should therefore be the endeavor to acquire such facility, not only in sending but in receiving, that *habit* will come to the aid even after the lapse of considerable time.

Minor parts of the instrument should be dismounted only to effect repair, for which purpose spare parts are furnished on requisition. All steel should be preserved from rust, and tangent-screws and bearings from dust and grit. The mirrors should invariably be wiped clean before using. In case of accident to the sun-mirror, the station mirror may be made available as such by removing the paper disk.

For permanent stations, an eight-inch mirror is contemplated, with provision for attachment to a post, the stump of a tree, or to some other firm base, by means of screws, dispensing entirely with the tripod.

The range over which signaling may be effected by means of this instrument, under favorable atmospheric conditions, is limited only by the convexity of the earth. The square mirror is adopted in preference to the round, as containing about one-fourth more reflecting surface for practically the same packing space.

Signaling at moderate range by night may be effected by *moonlight;* also by the employment of *artificial light.* This latter fact makes possible practice with the instrument in the squad-room."

NIGHT SIGNALS.

For both signal stations and vessels, the electric light will be used under most circumstances, and bombs or rockets, showing various colored stars, when the circumstances make it necessary. Illuminated and electrical semaphores have been tried, and might be of use on shipboard; but for the shore stations where the electric light is not furnished, the Army flash light or brick-wood torch must be used. At the large stations the captive balloon might be tried with success. The following is a description from the Manuel du Matelot-Timonier: "The rays of electric light reflected by a mirror are thrown upon a white balloon above the reflector. The lower portion of the balloon will be brilliantly lighted and visible around the horizon. A screen placed before the reflector serves to interrupt the luminous rays, and by this means the long and short flashes are shown on the balloon. When the night is dark and damp the balloon need not be used, as the luminous trail is then very plain. The long and short flashes may also be made on the summit of a mountain or on the clouds." This latter means would be used by the lookout vessels signaling to shore when below the station's horizon. Captive balloons have been the subject of experiment when they were lighted by electric lights in the interior, or by a surrounding circle of lights, the lights being started or flashed by the touch of a key, but they have not proved a success.

CARRIER PIGEONS.

The carrier pigeon has been used to convey information for many years, and has proved a most useful military messenger at many sieges, etc. But the systematic use and development of them had been due mainly to private societies, until the siege of Paris, 1870–71. During that siege they were found so invaluable that the French have since made great efforts to develop their use, and now the Military Pigeon Service has become a part of the military system of almost every country in Europe. France, Germany, Austria, Russia, Italy, Spain, and Portugal all have a Military Pigeon Service. The service in France may be shown by a few words from a military paper: " An exchange of correspondence between the central authority, the governors of fortresses and entrenched camps, and the commanders of armies, is ensured." Since this the French have entered into a series of experiments at Toulon, initiated by Vice-Admiral Bergasse du Petit Thouars and the Société Forteresse. The first attempt was to domesticate the pigeon on board the St. Louis, the artillery practice ship. In order to accustom the pigeons to the report of guns, the cote was placed near two 19-c. and two 24-c. guns that fire an average of six hundred rounds a week. The following extracts are from a letter written by the aide-de-camp of the Vice-Admiral, Ch. Duperré, Commander-in-chief and Prefect of Toulon: "These experiments were of two kinds. One, which succeeded perfectly, was to establish communication between a ship at sea and a carrier pigeon station on shore; the other, for the purpose of studying the feasibility of keeping and acclimating the pigeons on board ship, and the possibility of establishing communication between the shore and a vessel in the offing having a pigeon-cote on board; also from one vessel to another. The experiments have demonstrated the fact that the carrier pigeon adapts itself perfectly well to life afloat, and even breeds on board ship, but they have been less conclusive in the matter of communicating between vessels, and these attempts will have to be repeated. Our naval carrier pigeon-cote, placed on the after part of the vessel, is shaped like a small Swiss cottage, with an inside capacity of 3 cubic mètres, and can receive eight couples of pigeons. In the rear are the traps by which the pigeons enter and leave the loft, and in front is a door opening into it. For the purpose of ventilation, a number of screened apertures are made in the fore and aft partitions that can be closed at pleasure. Inside the loft are two tiers of plaster nests, separated from each other by a light partition and covered with a roof; each nest is numbered. The feed and water pans are on the floor of the loft, which is slightly raised from the deck and covered with a thin layer of dry sea-sand."

Germany has the most complete military system in the world, and all its fortresses communicate with central points by means of pigeons. The whole of the northern coast is studded with pigeon stations, which are under control of the Minister of Marine. Experiments have been made by the naval authorities on homing pigeons on board men-of-war, so that messages may be sent to the ship from shore. It is said that the birds experience no difficulty in recognizing their own ship amongst a number of others. Austria is gradually completing a carrier-pigeon system for military purposes. The Russian system is still imperfect. There are 12 pigeon stations established in various parts of Italy, under the supervision of the engineer in territorial command at Rome. There are stations at Massowa and Assab for intercommunication between those places. The pigeons of each station are divided into as many groups as there are places to be communicated with, and these groups ply the same line always. Communication between the island of Maddalena and Rome (240 kiloms., all sea) has been kept up in all weathers, and pigeons have arrived close to Naples from Cagliari (450 kiloms.). During the squadron manœuvres reports were sent by pigeons, and often arrived many days before the dispatch vessel sent at the same time.*

There are only a few stations in Spain. In Portugal there are pigeon stations at Lisbon, Oporto, Setubal, Tameas, Vedras Novas, Elvas, and Mafra. In Denmark all carrier pigeons are private property, but the War Office has recognized the utility of the pigeons by granting money prizes for some of the races. France is the only country that has made careful experiments and adopted a system connecting the fleet and the coast. The first trouble was that the noise of the guns frightened the pigeons; but by rearing them near the guns, they soon became accustomed to the noise, and when liberated from the various vessels of the fleet during target exercise, would form groups above the smoke, sometimes mingling together, but never losing their own ship. Messages have been sent to the shore in a number of cases, but the experiment of communicating between ships has not been quite successful. Still it may be developed so that scouts sent out in certain directions from the fleet can send back information by the pigeons, and telegrams from shore can be sent to the fleet when beyond the range of heliograph or electrograph.

UNITED STATES.

While there has been no attempt to establish a system of signal stations, we have several government establishments, whose operations stretch along our coast line, that might be used in creating a system of naval coast signals. There are numerous light-houses and light-ships that are under the management of the Light-House Board; about 300 of these are in good positions for signal stations, and about 2700 men are employed in this service. Many of the army stations along the coast, under the Weather Bureau, are connected by telegraph lines and cables. On July 1, 1887, there were 331 miles of sea-coast line in operation. The Army have transferred a portion of their lines to the life-saving service, and many of the life-saving stations are connected by telephone lines. Most of the stations along the coasts of New Jersey, Virginia, and North Carolina have the telephone. There are 203 life-saving stations on the Atlantic, Pacific, Gulf, and Lake coasts. From the above it may be seen that a complete system of signal stations could be put in operation with very little additional expense, and when these services form a part of the Naval Reserve, they can be readily adapted to war uses while still fulfilling their important peace duties.

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*Journal R. U. S. Institution, No. 141.

HOMING PIGEONS.

There is ample material in our country for establishing pigeon stations. There have been many fanciers devoted to the sport for some years. The Federation of American Homing Pigeon Fanciers includes a large number of clubs scattered over the country, and several journals are devoted to this subject. Lieutenant V. L. Cottman, U. S. N., in charge of the Branch Hydrographic Office in New York, has been kind enough to take a great interest in the subject, and has collected considerable information from the fanciers in the neighborhood of that port. This shows that there is great enthusiasm among the pigeon fanciers, and that they have not confined themselves to training their birds for races over land, but have also made experiments from seaward. From 1855 until the laying of the Atlantic cable, homing pigeons were used to take the news from the transatlantic steamers to the Sandy Hook telegraph station and thence to New York. The pilot boats have experimented with the birds at various times, and birds have been taken out in various steamers and yachts and let fly when out of sight of land. The birds of the Plainfield Club, New Jersey, have been liberated at sea many times, and F. R. Stevens and J. H. Doane, of that club, have federation records for birds liberated 300 miles from Plainfield and 100 miles from land.

There is, of course, great difference in the birds as to speed and reliability. Some fanciers say they are utterly useless in stormy weather and fogs, while others maintain the contrary. Mr. Stevens had two birds return from Manassas, Va., to his loft in a heavy rain and fog, and they made 695 yards per minute. About five hundred miles is the limit that can be attempted over the sea, and the best birds can do this in from 13 to 14 hours. In making these long flights they are liberated early in the morning, so that they may reach their loft before dark. A loft for homing pigeons has been started on board the New Hampshire at Newport, R. I., and the Army Signal Office have established a pigeon station at Key West. This station is being conducted in a systematic manner and according to the most approved principles. They have birds already trained to bring back messages from 100 miles out from any positions to the eastward, and before long they will have birds for any distance up to 400 miles. This is a commencement that can be readily extended, and it costs the Government but very little. The fanciers throughout the country are ready to give the Government their hearty support, and will assist with their experience in any experiments that may be undertaken; and it is to be hoped that when we have a fleet we may have a complete pigeon service for naval purposes, and this, with a system of naval coast signals, will enable our fleet to be handled in the most effective manner for the defense of our coast.

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U. S. NAVAL INSTITUTE, NEWPORT BRANCH,

JANUARY, 1889.

NOTES ON THE LITERATURE OF EXPLOSIVES.*

By CHARLES E. MUNROE.

No. XIX.

U. S. Letters Patent No. 393,107, November 20, 1888, have been granted W. E. Hicks, of Brooklyn, N. Y., for a machine for the throwing of projectiles filled with high explosives, in which he avails himself of the so-called centrifugal force as his projecting agent. The machine consists of two steel disk-wheels placed concentrically side by side upon a shaft. To this shaft a pulley wheel is attached, the revolutions of which give a velocity sufficient to discharge projectiles with the necessary force. The projectiles are placed in pairs on the opposite sides of the periphery of the wheel, and thrown two at a time, one from each side of the wheel, by pulling a lanyard. This unlocks an automatic apparatus holding the projectiles, and releases them at any given point in the revolution of the wheel, so that they can be thrown at any angle desired between the zenith and the horizon. The whole apparatus is set upon a turn-table, so that it may be trained in any direction. The carriers are so arranged as to fly upwards at the instant of discharge, and thus to counteract the centripetal tendency of the curvilinear trajectory. The initial velocity is, of course, limited by the tensile strength of the steel firing chambers. The application of this force to the throwing of projectiles is older than the time of David, and attempts to apply it to modern uses have been made by Winans, and probably by Brunel and others. One peculiarity of the gun, or engine, as it might perhaps more properly be called, is its comparative noiselessness. There being no expansion of gases, and no vacuum, there is no report of any kind, the only sound being the whiz of the shell as it passes through the air. There is neither flash nor smoke, report or recoil, and there is nothing to apprise an enemy of the whereabouts of the gun, and the destroyer might come in the midst of an enemy unseen and unheard. It is hoped that a thorough trial of this new gun will be made from which data may be obtained concerning its efficiency, range, and practicability as a weapon of warfare.

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* As it is proposed to continue these Notes from time to time, authors, publishers, and manufacturers will do the writer a favor by sending him copies of their papers, publications, or trade circulars. *Address Torpedo Station, Newport, R. I.*

The combination shot and shell designed to be used in this engine is of regulation shape, having a solid steel head for the purpose of producing the greatest penetration upon impact. It is provided with a steel rod or percussion striker, extending through the center, one end of which is adjusted in the apex of the ogival head, while the other end rests against a percussion primer, which upon impact explodes the charge of explosive, thereby producing a double blow, by impact of the shot and by the subsequent explosion.

The shot can also be exploded submarine, being provided with a device which will produce an explosion in case the target should be missed. Should that target be a ship, the effect would not then be wholly lost.

The apparatus devised by Mr. Hicks is illustrated, and the data used in determining its theoretical efficiency is given in the *Army and Navy Jour.* **26**, 302, December 15, 1888, and also more fully in the *Sci. Am.* **59**, 399–400, December 29, 1888.

U. S. Letters Patent No. 359,491, March 15, 1887, have been granted Louis Bagger, of Washington, D. C., for a primer for igniting explosives, and for which he makes the following claims:

1. A primer for igniting combustible or explosive compounds, the igniting charge of which is composed of potassium, or an equivalent material having a stronger chemical affinity for oxygen than the affinity which exists between oxygen and hydrogen in the formation of water, whereby such primer is ignited in contact with water.

2. The combination with an explosive shell, of a primer or igniting device composed of material possessing a stronger chemical affinity for oxygen than the affinity which exists between oxygen and hydrogen in the formation of water, whereby the shell is exploded on contact with water.

3. The combination with an explosive shell, of a primer or igniting device composed wholly or in part of the metal known as "potassium," whereby the shell is exploded on contact with water.

4. The combination with an explosive shell and a primer therefor, having an igniting charge composed of potassium, or an equivalent material having a stronger chemical affinity for oxygen than the affinity which exists between oxygen and hydrogen in the formation of water, of an air and waterproof covering for protecting such primer, as set forth.

5. The combination with a percussion primer of any desired construction, of an igniting device composed of material possessing a stronger chemical affinity for oxygen than the affinity which exists between oxygen and hydrogen in the formation of water, whereby such primer is exploded on contact of the igniting device with water.

6. The combination with a percussion primer of any desired construction, of an igniting device composed wholly or in part of the metal known as "potassium," whereby the primer is detonated by contact of the igniting device with water.

7. The combination with a percussion time-fuse of any desired construction, of an igniting device composed of material possessing a stronger chemical affinity for oxygen than the affinity which exists between oxygen and hydrogen in the formation of water, whereby such fuse is fired on contact of the firing device with water.

8. The combination with a percussion time-fuse of any desired construction, of an igniting device composed wholly or in part of the metal known as "potassium," whereby on contact of the potassium with water the fuse is ignited, as set forth.

9. A fuse adapted to be ignited by contact with water, consisting of any suitable combustible material confined in whole or in part within a tube or other envelope, and provided with a primer or igniting device whereby the fuse is ignited, being composed of material possessing a stronger chemical affinity for oxygen than the affinity which exists between oxygen and hydrogen in the formation of water.

10. A fuse adapted to be ignited by contact with water, consisting of any suitable combustible material confined in whole or in part within a tube or other envelope, and provided with a primer or igniting device inclosed within or covered by an envelope of suitable material, said primer or igniting device whereby the fuse is ignited being composed wholly or in part of the metal known as "potassium."

Mr. Bagger states that the invention relates more particularly to an improved method of igniting the explosive charge in shells and torpedoes through the direct action of the water into which the shell may drop or the torpedo be immersed, and that it may also be used with advantage in life buoys, life rafts, and other life-saving apparatus; for igniting signal lights, sounding high-water alarms, and for numerous other purposes where it is desired to ignite an explosive charge or other combustible material instantaneously through the direct action of water, which may be either salt or fresh, so that the invention is equally adapted for use on the open ocean and in inland waters.

Of its advantages, he states that it may be applied to all kinds of explosive shells equipped with either percussion primers or time-fuses. Where the primary object is to explode the shell at the moment of contact with the ship or other object aimed at, the improvement assumes the form of an auxiliary device for causing the explosion of the shell if it drops into the water. Experience having shown the difficulty of squarely hitting, with heavy ordnance, a movable target, whereby the shell without exploding simply sinks to the bottom, by providing a shell with this auxiliary fuse or "water primer," as he calls it, while it does not in the least interfere with its explosion by percussion if it does strike the object aimed at, when it fails to explode and simply drops into the water it will, the instant it reaches the water, explode through the action of the auxiliary fuse, scattering its fragments over a large area of water surface, and subjecting objects at a considerable distance to the disastrous effects of the air-wave or concussion resulting from the explosion of a charge of dynamite or other powerful explosive with which it may be charged. This object is accomplished by providing the shell with an auxiliary fuse, and priming it with material possessing a stronger chemical affinity for oxygen than exists between the two components of water. Of such materials, potassium he considers particularly adapted to his purpose, owing to its excessive chemical affinity for oxygen and the readiness with which it can be obtained in commerce.

The so-called "water-primer" consists of a thin plug, disk, or film of this material, or its equivalent, introduced through a hole bored through the shell to the chamber containing the explosive material, which is charged with gunpowder, gun-cotton, or any suitable explosive. The hole and fuse are then covered or plugged with a thin disk or film of potassium, which, to protect it from oxidation, may be placed in a glass tube open on the lower side, where it is in contact with the powder in the fuse. If the shells are to be stored for any considerable length of time before use, a thin film or coating of paraffine, petroleum paste or similar material may be applied to the under side of the disk of potassium, effectually preventing oxidation.

Other devices may be employed for protecting the water-primer from the action of the atmospheric air, viz. a plug fitting air-tight and bearing with its inner end against the primer inserted in said aperture. On firing, this plug is to be removed, or it may be made of material which will be fractured by the explosion when the shell is fired, or of some soluble material which will dissolve instantaneously when the shell comes in contact with the water. And, again, the potassium primer may be protected by a covering in the nature of a plaster, which may be removed on firing, or composed of material which will instantaneously dissolve when the shell touches the water. For practical purposes, a piece of canvas treated with a composition of paraffine, rock-oil, and cement answers admirably and protects the water-primer indefinitely. On firing, this plaster can readily be torn off, so as to expose the primer to the action of the water.

The fuse-channel may be made to communicate with the percussion primer instead of the chamber containing the charge, and the primer can also be used in combination with a time-fuse by drilling a hole communicating with it, showing that the device may be used in combination with either a percussion or time-fuse, instead of in direct combination with the body of the shell.

When the shell is to be used, but not before, the potassium primer is exposed by breaking or removing its envelope. Should the shell drop into the water, the chemical action of the exposed primer results in the immediate explosion of the shell the moment the primer touches the water, the heat developed being more than sufficient to ignite the fuse and explode the charge within the shell even before this has been completely immersed in the water. However, by graduating the thickness of the primer disk, the fuse may be made so that explosion will not take place until the shell is fully immersed.

In its application for the exploding torpedoes the fuse may conveniently be made of a piece of gas-pipe filled with any suitable material for a fuse, the upper part of which is made of glass or other fragile material to be filled with a suitable quantity of the water-primer; Mr. Bagger preferring a tube similar to a barometer tube, sealed at the top, and filled, or partially so, with potassium, care being taken to provide a water-tight connection. When a vessel passes over it, touching the glass tube, the tube is fractured, the potassium exposed, and the instantaneous explosion follows. If the torpedo and fuse are made properly, *i. e.* water-tight, the torpedo may remain immersed for any length of time without the least deterioration. It is difficult to pick up these torpedoes by "torpedo finders," the least touch of a pole breaking the glass end of the fuse and producing explosion.

These are but a few of the many purposes this invention may be applied to—igniting Roman candles, or signal lights on life-rafts, through direct action of the water the moment the buoy is thrown therein, or used in shells adapted to float and primed with one of his water-primers so that the shell will take fire on striking the water, and when its contents are ignited, illuminating the surrounding neighborhood. Other purposes, for war as well as in peace, readily suggest themselves.

It will be noticed that Holmes, in his self-lighting, inextinguishable signal light (a full description of which will be found in *Ding. Poly. Jour.* **201**, 203–205 ; 1871), avails himself of this principle, though he employs calcium phosphide. In this connection we call attention also to these Notes, *Proc. Nav. Inst.* **11**, 770–771 ; 1885.

Capt. E. L. Zalinski has invented a shell for high explosives which it is claimed may be used with safety. This shell has a double casing, each of ordinary cylindro-conoidal shape; but the outer is struck with a sharper ogival, so that the two casings are separated in front by an air space, and a collapsible head is formed. In the nose of the inner casting is an elastic cushion of rubber, loose asbestos, or some kindred substance. The bursting charge is built up in the body of the shell as follows: In the interior is a core-cylinder formed by a casing of highly alkaline asbestos paper, with a diameter equal to about one-seventh the diameter of the shell. This cylinder is filled with some very sensitive explosive, such as dynamite,. and in the base is a detonator actuated by an electric fuse. A substance such as nitro-gelatine, more powerful but less sensitive than dynamite, is used to fill up the shell; but between it and the inner casing of the shell there is asbestos paper, made strongly alkaline. These two paper envelopes absorb any free acid and serve to protect the charge from the action of external heat. Over the charge, and just in the rear of the elastic cushion, is placed a disk or segment of highly camphorated nitro-gelatine, or other similar compound not very liable to explosion by concussion. When the projectile strikes the object, the charge is not fired by the impact, but the collapsible head actuates an electric arrangement which explodes the detonator, instantaneously or after a fixed interval, as may be arranged. The detonator explodes the dynamite, which in its turn acts as a detonator to the nitro-gelatine. The arrangement in the front of the projectile effectually prevents the concussion of impact from exploding the charge, which is thus fired from the rear, and the maximum effect produced. Small batteries are contained in the base of the shell, and in connection with them are electric primers, several being made use of in order to insure explosion. The circuits are not closed until the head of the shell collapses. The primer consists of two parts capable of being pressed into electric contact by the action of a spiral spring; in loading, however, these two parts are held away from each other by detents. On firing, these detents are held up to their work by the fluid pressure of the propelling agent, which enters through holes in the primer, as long as the projectile is in the bore. When the latter leaves the bore, the gas or air escapes out of the primer, the detents can no longer hold back the spiral spring, which brings the two parts of the primer together and closes this part of the circuit. It will thus be seen that the detent in the primer is merely a safety arrangement to prevent a premature explosion. When the head is collapsed by impact the circuit is completed, and the primer either fires the shell at once or lights an adjustable length of fuse composition, which can be made to explode the shell at any time-interval after impact. If the projectile falls into water, the concussion will not be strong enough to collapse the point of the shell, and the battery already referred to will not act. It is, in fact, desirable that the projectile shall have time to enter the water some distance, so as to get beneath a hostile ship before the explosion takes place. For this purpose one or more "delay action" batteries are provided. When the circuit-breaking arrangement in the primer above described is closed, the circuit of the cells of these batteries is completed; but no current passes, as one cell is left dry. This cell is provided with a cover which is broken on discharge, and which protects it against moisture until the projectile is fired. When the latter falls into the sea the water enters this cell, which becomes "alive," and the current passes to the detonator.

It has been attempted to impart rotation to the projectile of the pneumatic dynamite gun by screwing into it a "guiding tail," consisting of a spindle with vanes at the end. Zalinski proposes to make use of this spindle as follows: When the gun is fired, the air causes the spindle and shot to rotate together. When the projectile strikes the water the latter stops the rotation of the vanes, but that of the shell still continues, owing to its comparatively smooth surface; the spindle is therefore screwed out. This action is utilized to actuate either an electric or percussion fuse, as follows: Holes at right angles to its axis are bored through the screwed socket that receives the spindle-head, and in these pins can work. When the spindle-head is home, these pins are pressed outwards against the action of an antagonistic spring, which causes them to fall back into the socket when the spindle is removed. In the electric fuse, when the pin goes back into the socket, electric contacts, previously held apart by it, come together and complete the circuit. In the percussion fuse, a similar pin holds back a hammer from a detonating patch of composition. When the pin releases the hammer, the latter is urged forward by the action of a spiral spring, and explodes the charge.

In shells containing high explosives, both a base and a nose fuse should be used for greater certainty of action. In the base fuse a horse-shoe magnet, with its armature to the front, is made use of. Round this magnet insulated wire is coiled, and the ends are in connection with a primer. When impact takes place the armature is torn off and urged forward, and an inductive current passes round the wires and fires the primer. As an additional safeguard, the front of the armature is formed into the shape of a hammer, which impinges on a patch of fulminate. The same principle is applied to the nose fuse, except that the armature is fixed, and the magnet is pushed backward from it by the action of a spindle to which the magnet is attached, and which passes through the armature and projects at the nose of the shell. In this case also an induced current is made to fire the primer.—*Industries* 5, 579–580; 1888.

The Forum 6, 370–381; 1888, contains a most entertaining article by Park Benjamin, entitled "The New System of Naval Warfare," in which he takes a very sanguine view of the part which Mefford's gun is to play in future wars.

The *New York Herald* of June 16, 1888, states that for some time past experiments have been in progress at the Torpedo Station, Newport, R. I., with a new and powerful explosive which seemed suitable for use as a bursting charge for shells to be fired from heavy guns.

A firing test to determine its availability for this purpose was recently made at the naval ordnance proving ground at Annapolis, Md., the piece used being a six-inch gun kept for experimental purposes.

Eight rounds were fired successfully, but at the ninth round the shell, loaded with two and a half pounds of the new explosive, burst in the bore of the gun with terrific violence, breaking the gun into three principal pieces, which were thrown to a distance of nearly fifty feet. Although the gun was not of service type, having been built before the high-power guns were introduced, and being used only for experimental purposes, the nature of the fractures, which showed the metal to be of excellent quality, furnished a striking evidence of the tremendous power of the explosive which could destroy this gun with such apparent ease.

U. S. Letters Patent 393,634, November 27, 1888, have been granted Arthur Favier, of Paris, France, for a new explosive and method of making the same, according to the following claims:

1. As a new article of manufacture, an explosive consisting of a highly compressed intermixture of a nitrate and a hydrocarbon, as hereinbefore set forth.

2. The method of producing the hereinbefore described explosive, consisting in intimately mixing together a pulverized nitrate, such as specified, and a water-proof hydrocarbon fusible at a low temperature, and then agglomerating said mixture under high pressure, substantially as used for the purpose hereinbefore set forth.

In making his explosive, Mr. Favier takes a nitrate, such as ammonium nitrate, and a hydrocarbon, such as paraffine, places the mixture in a mold, which is heated by hot water or steam, and subjects the mass to a pressure which depends upon the density desired. If the density is to be 1.7, a pressure of about three hundred atmospheres is required. As a result of this operation he gets a mixture which is very permanent, and so insensitive to explosion that a very powerful primer of gun-cotton or a chlorate is required to explode it. For this reason he makes his explosive up with either hollow cylinders or spheres so formed that the priming charge may be placed in the center of the cartridge.

The *Boston Globe*, November 1, 1888, states that a new explosive called "Extralite," for which U. S. Letters Patent have recently been issued to Rudolph Ericsson, of New Britain, Conn., has been tested at that place. This powder looks like corn-meal, has the odor of oil of mirbane, and may be made over a stove. A quantity of it was placed in a fire and it refused to burn; another portion was saturated with kerosene and set fire to, when about one-half of it was slowly consumed; another portion was inserted in a cartridge of dynamite and the dynamite exploded with a fuse, but the extralite failed to explode; another portion, placed on a rock, was subjected to the blow of a sledge-hammer, but it was not exploded; and it is held that it cannot be exploded in the open by any means. A two-foot hole was then driven in a rock so hard that in the judgment of the quarrymen present two pounds of powder or one pound of dynamite would have been necessary to blast it, but nine ounces of the extralite, well tamped, shattered it to fragments. It is claimed that this explosive is safe to handle and ship, and is very cheap to manufacture. The manufacture for the trade is to be begun at once at New Britain. It is also stated that the French Government last year paid one million francs for the right to use it.

In this connection see Notes, *Proc. Nav. Inst.* **13**, 579–581 and 247–248; 1887.

We have already cited* here the preliminary notice of L. Gattermann's researches upon " Nitrogen Chloride." The complete account now appears in the *Ber. d. chem. Ges.* **21**, 751–757; 1888, and it contains a detailed description of the analytical operations. When the ordinary method of production by acting on a solution of ammonium chloride with chlorine gas is pursued, the resulting substance is invariably a mixture of the various chloramides. By washing out the ammonium chloride, and treating the moist mixture directly with chlorine, the trichloramide results. About one-half a gram of this product was heated in a thin-walled tube immersed in a beaker filled with vaselin. Up to 90° no change was observed, but about 95° a violent explosion occurred. As the effects of this explosion were most marked on the support which held the beaker, Gattermann claims that it is a characteristic of this explosive that the explosion takes place in a downward direction.

The applications which have been made of nitrogen tetroxide in the preparation of explosive substances led B. Setlick, *Listy Chem.* **11**, 241–242, to determine the yield obtained by the various methods of preparation of nitrogen tetroxide which are in use, and he obtained from 60 to 70 per cent of the theoretical yield by heating lead or calcium nitrate and by reducing starch with nitric acid. He also oxidized nitrogen dioxide with air and with pure oxygen, the nitrogen tetroxide formed being led through two cooled receivers to condense the gas, and then through sulphuric acid to dissolve the remainder. With air the yield was 138.6 grams (of which 18 grams condensed); with a mixture of equal parts of air and oxygen, 129.8 grams (of which 80.3 grams condensed) out of a theoretical yield of 156.8 grams. With oxygen alone the yield was 92.8 grams (of which 74 condensed) out of a possible 102 grams.—*Chem. Centr.* 461, 1888; *Jour. Chem. Soc.* 54, 913, September, 1888.

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* Proc. Nav. Inst. 14, 441; 1888.

B. F. Oettel describes in the *Chem. Zeit.* **11**, 1601, a very neat lecture experiment, which is performed by placing a small heap of finely powdered potassium chlorate on a piece of filter-paper, which is supported on a tripod, and saturating the heap with a solution of phosphorus in carbon bisulphide, which is left to volatilize. So soon as the bisulphide evaporates, the mass explodes with a loud report, and gives off clouds of smoke.—*Jour. Chem. Soc.* 54, 910, September, 1888.

Among the latest devices in the way of whistles are the curious chemical toys made with picrate of potash. When the whistling rockets and fire pieces first appeared, the whistling was commonly supposed to be produced in the same way as in ordinary whistles—by the air movements produced by their rapid motion. This is, however, not so. The operation is not at all like that of an air whistle, but the production of the sound is owing to the peculiar property of picrate of potash of whistling when it is burned. This effect is heard clearly with that salt when compressed in a tube, and the sonority may be augmented by the addition of various substances. Such a composition may be formed, with no other danger than usually attends the manipulation of explosives, by triturating a mixture of 15 parts of picrate of potash and one part of Judean bitumen. It is then charged into a pasteboard tube a little less than half an inch in its interior diameter, and some two and a half inches long. The tube is closed at one end by a plug of closely tamped clay. The composition is introduced in small charges, evenly compressed, till the tube is filled to within about three-quarters of an inch of the open end. The whistle may be wired upon the cartridge of a rocket, when it should be furnished with a cap penetrated by a quick match, which, entering the picrated composition, is also inserted into the throat of the rocket so that the two fireworks shall be inflamed at the same time. The sound of these whistles is sharp at first, and passes gradually as the tube is emptied of its contents to a grave tone. By combining the whistle with various devices of fireworks, curious effects are produced, in accordance with which expressive descriptive names have been given to the artifices.

When the picrate whistles were first exhibited at Havre, on the occasion of the *Fête Nationale*, the spectators, irritated at the strident noise they made, and mistaking its origin, exclaimed: "Down with the whistling fellows! Duck them!" The enjoyment of the festival was much enhanced when the joke was explained.—*Boston Globe*, July 8, 1888.

An explosion of oatmeal dust, through which three men were killed, one fatally injured, and several badly bruised, and by which a three-story brick building was completely wrecked, occurred December 10, 1888, at the oatmeal mill of David Oliver, on North Halstead Street, Chicago.—*Newport News*, December 11, 1888.

The *Eng. News and Contract Jour.* **19**, 25; 1888, contains a very full account, which is well illustrated, of a remarkable boiler explosion.

A. Smolka, *Monatsh.* **8**, 391–398, has prepared a number of "salts of picramic acid," $C_6H_2.NH_2.(NO_2)_2.OH$, with the more commonly occurring bases, either by direction of the acid on the carbonates or by metathesis, and from the study of their properties he finds that if one of these salts is slowly heated it is quietly decomposed, but if rapidly, explosions occur, especially with the sodium and lead salts. —*J. Chem. Soc.* **54**, 52; 1888. The explosive nature of the picramates was pointed out by Girard.—*Compt. rend.* **36**, 421, and *Watts' Dict.* **4**, 406–407; 1868.

Among a large number of "derivatives of di-β-naphthylamine" which C. Ris has obtained, *Ber. d. chem. Ges.* **20**, 2618–2628; 1887, is the hexanitrodi-β-naphthylamine, $C_{20}H_9N(NO_2)_6$, which, when mixed with excess of cupric oxide, decomposes with explosive violence.

The formation of "aniline salts" with inorganic acids has engaged the attention of A. Ditte, *Compt. rend.* **105**, 813–816, 1887, and, among others, he has obtained the chlorate by mixing cold concentrated solutions of sodium chlorate and aniline hydrochloride, which he finds to be very unstable and to decompose rapidly even in the dark at 0°, while at the ordinary temperature it quickly becomes black and detonates violently at about 20°.

Among other results of his investigation of the properties and constitution of dinitrosocresorcinol, $C_6HO_2.(NOH)_2.CH_3$, *Ber. d. chem. Ges.* **20**, 3133–3137; 1887, Sv. Kostanecki finds that it explodes when heated in a capillary tube above 160°.

The chloro-, bromo-, hydroxy-, nitro-, and amido-derivatives of benzoquinone have long been known, but attempts to obtain carboxyl derivatives have hitherto been unsuccessful. In *J. Chem. Soc.* **53**, 428–459; 1888, J. U. Nef gives the results of his experiments, which were undertaken to fill this gap, under the title "Carboxyl-derivatives of Benzoquinone." Durene was chosen as the starting-point, owing to the special interest attaching to the production of quinonetetracarboxylic acid, $C_{10}H_4O_{10} = C_6O_2(COOH)_4$, which has the same percentage composition as croconic acid, $C_6H_2O_5$, obtained by Gmelin from the explosive bye-product of potassium manufacture, and which has recently been critically studied by Nietzki and Benckiser.*

Among the bodies which Nef has produced is dinitrodurylic acid, $C_6(NO_2)_2(CH_3)_3.COOH$, the calcium salt of this acid being violently explosive when heated on platinum foil; diamidodurylic acid, $C_6(NH_2)_2(CH_3)_3.COOH$, which furnished a silver salt which is unstable towards heat and light and explodes when heated quickly on platinum foil; dinitropyromellitic acid, $C_6(NO_2)_2(COOH)_4$, whose silver salt explodes on heating; and dihydroxypyromellitic acid, $C_6(OH)_2(COOH)_4$, which also furnished a silver salt which is explosive when quickly heated on platinum foil. If heated slowly, however, a volatile yellow substance sublimes.

O. Fischer and E. Hepp, in continuing the examination of "Paranitrosoaniline," *Ber. d. chem. Ges.* **21**, 684–686; 1888, find that when nitrosoaniline is treated with phenylhydrazine hydrochloride, a compound, $C_{12}H_{14}N_4O$, is obtained which crystallizes in yellow needles, and when carefully heated melts at 125° with decomposition, but which explodes when more quickly heated. Similar compounds with phenylhydrazine seem to be given by all nitroso-bases.

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* Proc. Nav. Inst. **12**, 192; 1886.

Among the "Orthamidoazo-compounds of Xylene and Pseudocumene" obtained by T. Lincke and H. Jaenke, *Ber. d. chem. Ges.* **21**, 540–548; 1888, is the xylene diazoimide, $C_{16}H_{17}N_5$, which melts at 77°, decomposes at 85° and detonates when quickly heated.

In studying the "Quinone-dioximes," R. Nietzki and A. L. Ginterman obtained the toluquinonedioxime in the form of needle-like crystals which explode at 220° without melting, and the 1:4-dinitrosonaphthalene in the form of a yellow non-volatile powder which explodes at 120°.—*Ber. d. chem. Ges.* **21**, 428–434; 1888.

The dinitro-orthotolidine, $[Me_2:(NH_2)_2:(NO_2)_2 = 3:3':4:4':5:5']$, in the form of shimmering, garnet-red needles which melt at 266°–267° and explode a few degrees higher, has been obtained by A. Gerber, while investigating the "Derivatives of Orthotolidine."—*Ber. d. chem. Ges.* **21**, 746–750; 1888.

In a paper in the *Ber. d. chem. Ges.* **20**, 2027; 1887, J. U. Nef has shown that nitranilic acid salts can be readily obtained by the action of nitrites on chloranil. In discussing "The Constitution of the Anilic Acids," *Am. Chem. Jour.* **11**, 17–26; 1889, he describes a simple method for the production of sodium nitranilate and for isolating the acid from this salt. He finds that pure dry nitranilic acid, $C_6N_2O_8H_2$, may be kept for months without undergoing decomposition, but on heating it explodes without melting at a high temperature. The salts of nitranilic acid possess at ordinary temperatures an extraordinary stability. They are all explosive, especially the mercuric salt. In their entire chemical and physical behavior they show a great resemblance to the salts of the nitro-derivatives of the fatty series, which undoubtedly have the metal bound directly to carbon. They also show resemblance to the salts of fulminic, barbituric and dilituric acids.

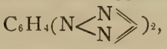
In studying the "Action of Nitroso-bases on Phenylhydrazine," O. Fischer and L. Wacker have obtained $C_{14}H_{16}N_4O$ by acting on nitrosodimethylaniline (3 mols.) with phenylhydrazine (2 mols.).

This substance, which the authors think may be the diazobenzene-nitrosodimethylaniline, is obtained in splendid yellow needles or plates, by carefully adding water to the alcoholic solution. It melts at 103° with decomposition, and detonates when quickly heated. When the solution in chloroform is heated it decomposes with explosive violence and liberation of carbonic anhydride.

By acting on nitrosodiphenylamine in acid solution with phenylhydrazine, the benzenediazonitrosodiphenylamine, $C_{18}H_{16}N_4O$, was obtained in crystals consisting of lustrous, gold-colored plates, which became greenish when exposed to light, melted with decomposition at 112°, and detonated when quickly heated.—*Ber. d. chem. Ges.* **21**, 2609–2617; 1888.

While investigating the properties of "Vinylamine and Bromethylamine," S. Gabriel obtained hydroxyethylamine nitrate, $OH.CH_2.CH_2.NH_2.HNO_3$, by boiling bromethylamine nitrate with silver nitrate, or by evaporating vinylamine with an excess of nitric acid. The substance forms flat, colorless, hygroscopic crystals which melt at 52°–55° and explode on further heating.—*Ber. d. chem. Ges.* **21**, 2664–2669; 1888.

Under the title of "Oxidation of Glycerol," E. Fischer and J. Tafel describe a method for the production of lead glyceroxide by the reaction of lead hydroxide on glycerol in aqueous solution, and purification with ether and alcohol. The dry product thus obtained contains small quantities of nitric acid (from the lead nitrate used for the hydroxide). It explodes when heated, and takes fire when placed in contact with chlorine or bromine.—*Ber. d. chem. Ges.* **21**, 2634–2637; 1888.

As a result of his continued "Researches on the Diazo-compounds," P. Griess, *Ber. d. chem. Ges.* **21**, 1559–1566; 1888, has obtained the paraditriazobenzene,  $C_6H_4\left(N\mathord{<}\genfrac{}{}{0pt}{}{N}{N}\mathord{\gg}\right)_2$, [1 : 4], which explodes with extreme violence when heated above its melting point; metamidotriazobenzoic acid, $COOH.C_6H_3(NH_2)N_3$, [1 : 3 : 5], which detonates when heated in the dry state; and metaditriazobenzoic acid, $COOH.C_6H_3(N_3)_2$, [1 : 3 : 5], which, when heated, explodes with the formation of a black cloud.

In studying the "Action of Nitrous Acid on Certain Organic Bases," W. Lossen and F. Mierau have obtained dinitrosobenzenylamidine, $C_{14}H_{14}N_6O_2$, by the action on benzenylamidine in an acid solution. This substance crystallizes in leaves which are sparingly soluble in cold water or alcohol, more readily in hot water, very readily in hot alcohol, but almost insoluble in ether. It explodes when heated to 178°, and is decomposed by an excess of acid, with evolution of gas.

By adding potassium hydroxide to a hot alcoholic solution of this compound, potassium dinitrosobenzenylamidine, $C_7H_6KN_2(NO)_2$, was obtained. This body crystallizes in needles which are readily soluble in water, sparingly in alcohol, and insoluble in ether. In the dry state the salt is very explosive, but in aqueous solution it can be boiled without any decomposition taking place. An aqueous solution gives precipitates with barium chloride, lead acetate and the like, which are also explosive in the dry state.—*Ber. d. chem. Ges.* **21**, 1250–1256; 1888.

H. Alexander finds, *Chem. Centr.* 1254–1255; 1887, that the following "Hydroxylamine Platinum Bases" are all explosive: Platoso-dihydroxylamine hydrochloride, $Pt(NH_3O.NH_3OCl)_2$; platoso-dihydroxylamine hydroxide, $Pt(OH)_2.4NH_3O$; platino-dihydroxylamine sulphate, $PtSO_4.4NH_3O + H_2O$; platoso-dihydroxylamine hydrochloride platinous chloride; platoso-hydroxylamine hydrochloride, $Pt(NH_3OCl)_2$. Free hydroxylamine, acting on platinous chloride, gives rise to the compound $OH.PtCl_4.4NH_3O + 2H_2O$, which explodes at 140°–150°. It is believed that by another reaction, platinum nitrogen chloride, PtNCl, together with a double hydroxylamine salt, was obtained.—*J. Chem. Soc.* **54**, 425–426; 1888.

We have previously noted* that T. Klobb had discovered several compounds of ammonia with metallic permanganates which exhibited marked explosive qualities. He has since continued his investigations (*Bull. Soc. Chim.* **48**, 240–244) and has obtained the luteocobaltic permanganate, $Co_2(MnO_4)_6.12NH_3$, which detonates when heated and explodes when struck; the luteocobaltic chloropermanganate, $(Co_2.12NH_3)Cl_4.2MnO_4$, which detonates when heated rapidly, but does not explode on percussion; and a compound of luteocobaltic permanganate, luteocobaltic chloride and potassium chloride,

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* Proc. Nav. Inst. **13**, 424; 1887.

$(Co_2.12NH_3)Cl_2.2KCl.4MnO_4$, which behaves like the preceding salts when heated.—*J. Chem. Soc.* **54**, 230; 1888.

In a paper entitled "On Manganese Trioxide," by T. E. Thorpe and J. F. Hambly, *J. Chem. Soc.* **53**, 175–182; 1888, the authors state that the chemical changes attending the action of sulphuric acid upon dry potassium permanganate have been differently described by different observers. It would seem in the first place that the nature of the reaction is very considerably modified by the purity of the salt and the strength of the acid. Wöhler, *Annalen* **86**, 373, observed that when concentrated oil of vitriol was poured over the crystallized salt, the permanganate was decomposed with explosive violence and with the evolution of much heat and even flame, and the formation of a cloud of finely divided oxide of manganese, large quantities of oxygen being simultaneously disengaged. Hence Wöhler concluded that free permanganic acid is a gas which at the moment of its liberation is decomposed by the heat of the reaction into oxygen and manganese dioxide. It is not improbable that the phenomena thus described by Wöhler were to some extent caused by the presence of potassium chlorate or perchlorate in the permanganate, for the authors find that pure dry potassium permanganate dissolves readily and quietly in the concentrated acid without any very extraordinary rise in temperature. If concentrated sulphuric acid is used, a clear sage-green solution will be obtained. If the monohydrated acid, $H_2SO_4.H_2O$, is employed, the color of the solution is dark brown, and it is seen to contain a number of oily drops which gradually sink, forming a dark reddish-brown liquid, which remains fluid at —20°. This substance is extremely unstable; on exposure to the air it slowly evolves oxygen, and the gaseous bubbles as they burst at the surface of the liquid form a violet-colored cloud. It is highly hygroscopic and gradually decomposes under the action of the attracted moisture. It is apparently non-volatile, it may be heated under reduced pressure to about 60° or 65° without the slightest evolution of vapor. At higher temperatures it is decomposed with a sudden and violent explosion into oxygen and manganese dioxide. The rapidity of the decomposition is probably due to the action of the separated manganese oxide, since Thenard has shown that a minute quantity of this substance, when added to the liquid, instantly resolves it, even in the cold, into these products. Silver oxide acts in the same way. It sets fire to paper, and explodes with hydrogen sulphide and the vapors of alcohol and ether. The composition of this body was found by Aschoff, *Pogg. Ann.* **3**, 217, to be Mn_2O_7, manganese heptoxide.

H. Debray and A. Joly state, regarding the "Ruthenium Oxides," that when ruthenium is heated in oxygen at a temperature above the melting point of silver, a portion is converted into peroxide, which is formed at a temperature of about 1000° and decomposes with explosion when cooled to 108°, but can be isolated by rapid cooling. This body affords another instance of a body which is decomposed by heat and yet is formed at a high temperature.—*Comptes rend.* **106**, 100–106; 1888.

In an article on the "Chemical Action of Light on an Explosive Mixture of Chlorine and Hydrogen," *Ann. Phys. Chem.* **32**, [2], 384–428; 1887, E. Pringsheim discusses the phenomena observed by Bunsen and Roscoe, and the theory which they offer to account for them, to which he takes exceptions while he offers a new theory of his own.

T. Bayley states in the *J. Soc. Chem. Ind.* **6**, 499-500; 1887, that when an assay of nitre in sulphuric acid is made in the nitrometer, an error is caused by the absorption of nitric oxide when the acid contains iron. Nitric oxide, shaken with mercury and pure sulphuric acid, suffers no absorption, nor does mercury pass into solution in the acid unless the acid contains a small quantity of iron. On copiously diluting the acid by the addition of air-free water, and subsequently adding a solution of a ferricyanide to the cooled acid liquid, the blue reaction is readily obtained. The mercury seems to take no part in the reduction of the ferric salt, since the results can be equally well obtained if pure nitric oxide is passed through a set of Geissler bulbs charged with sulphuric acid containing ferric sulphate. The sulphuric acid in this case, as in the nitrometer, assumes a purple tint, which is characteristic of the reaction when it takes place in the acid, but not in the aqueous solution.—*J. Chem. Soc.* **54**, 388, April 1888.

Charles E. Munroe contributes to *The Chautauquan* **9**, 203–205; January, 1889, an article upon the "Effect of Explosives on Civilization," which is one of a series of articles on civilization and the causes and forces which have affected it, that have been prepared for a course of study in the C. L. S. C.

Through the courtesy of Mr. Wolcott C. Foster we have received a copy of a pamphlet of 24 pages, entitled "Explosives and their Composition,"* which contains his contributions on this subject that were printed in the *Engineering News*, June 30 and July 7, 1888. The arrangement is an alphabetical one, and the work is a handy and useful one for reference.

* No. 6, Engineering News Technical Library, New York, 1888.

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

PROGRESSIVE NAVAL SEAMANSHIP.

By Commander C. D. Sigsbee, U. S. N.

One of the vexed questions of the day within the Navy is that of seamanship; *i. e.* the relation of past seamanship to future seamanship. That experience with the new ships will settle the question satisfactorily is highly probable; but the more consideration we give the subject in advance, the sooner will we reach settled convictions through experience. At present there is an abundance of positive and conflicting condemnation of that which exists, which is equivalent to saying that there is a lack of conclusion as to what shall take its place. Even accomplished officers sometimes condemn with an exaggeration which must be accepted as a proof of earnestness rather than a precise measure of belief. For example, some assert that our standard work on seamanship is antiquated and should be discontinued in the course of study at the Naval Academy, not that *parts* of it should be discarded. Yet the last edition of that work was published in 1883, and embraces immutable principles of seamanship, in addition to sailing evolutions, and details of management and equipment not strictly applicable to the new and projected steel vessels.

But there are counter opinions and influences quite as strong, if not as assertive, tending to maintain unduly the old order of things because of its supposed effect in moulding officers and men to the character of the ideal seaman. This extreme opposition of opinion may do much harm outside the service, and within the service likewise; on the one side, by depreciating matters of continued importance, and inducing a cessation of effort on board vessels not of the latest type; and on the other, by retarding development on lines made plain by a vast deal of experience with modern vessels in foreign services. Between these extreme views there are others, supported by a stronger basis of observation and study, and which are likely to carry the day. To aid in the latter respect is one purpose of this paper, but I shall feel as gratified to be set right in one direction as to be approved in another. Another purpose may be stated as follows:

As head of the Department of Seamanship, Naval Tactics and Naval Construction, at the Naval Academy, consideration of our subject is forced upon me to an unusual degree, and I therefore venture to court the criticisms and suggestions, public or private, of other officers, with a view to profiting by them in my position.

The questions to be answered are: First, What shall we discard of the old seamanship? Second, What is likely to be required of us in the new order of things? Since officers are thoroughly informed with respect to the old seamanship, it is but natural that we hear far stronger opinions relative to the first question than to the second; and we find condemnation greatly preponderating over suggestion; in fact, there is very little *formulated* opinion in any direction. A field is therefore left open.

It must be admitted that it is difficult to circumscribe our subject, for now, more than ever, one branch of the profession merges with another; but let an effort be made by attempting a comprehensive definition of seamanship, which, if generally accepted, will make the task easier. Let us say, then, that *Seamanship*, as the art of the seaman, embraces a knowledge of vessels, their construction, equipment, fittings, and qualities, also their care, preservation, organization, management and direction under all circumstances. This leaves plenty of room for the inclusion of other specialties and their applications under other terms.

In attempting to establish the relation of a seaman to his art, we shall fail unless we consider the state of the art as we actually find it, and also as it tends to develop. We must value tradition as tradition, nothing more—that is, as a matter bearing on *esprit du corps*, not as necessarily governing practical applications of the present day. Considered in its proper relation, tradition should not be upset with violence, unless the emergency of change demands it; but when that demand is squarely made, we should be merciless towards mere sentiment. It should always be borne in mind, however, that in adopting new ideas we ought not to lose sight of that which is good and of continued application in the old.

At the outset it must be understood that I treat of *naval* seamanship, and that we still have in the service a number of wooden vessels of the old type, full-rigged and full-powered up to the standard of a few years ago. They are not nearly so handy under sail as the old sailing ships, but are handy to a fair degree. Under sail they will wear, tack after a fashion, heave-to, lie-to, cast, and will run free faster than many of their predecessors. In the absence of prophetic vision, let us assume that they will have ceased to exist ten years hence. Our officers are masterful on board these vessels, and for service on board them, the work on seamanship already cited remains excellent authority—unequaled published authority. Again, we have coming into life a new class of ships, not by a gradual transition from type to type, as the result of practical experience within our own service, growing with our growth, but placed in our charge with a comparative suddenness which constitutes an emergency—an emergency that we are expected to meet seriously and without flourish. It is the appearance or prospect of these vessels that renews and emphasizes the demand for a less conservative persistence in the old practices.

From what may be called the quarter-deck seaman's point of view, the essential differences between these new vessels and the old ones which remain are, diminution of sail power with increase of steam power, coal efficiency and coal endurance. The new cruisers can keep the sea for a long time, and cover a great distance at good speed under steam alone without renewing the coal supply. None of the new ships has more than two-thirds sail power, nor carries sail in excess of a bark rig, nor above topgallant sails. Some have only fore and aft sails for sail propulsion, others only fore and aft storm sails or no sails whatever. It is probable that none will have studding sails. None has head booms except the Chicago, and hers are light. The original design of the Newark provided for head booms, but that feature was abandoned. This marks a great and restrictive change in sail power, but will it be reversed and full sail power be reinstalled? Hardly. 1st, because the efficiency of any given area of sail for any given conditions remains fixed, whereas the efficiency of a ton of coal is constantly increasing with the improvements in machinery and methods. 2d, because dependence on sail in emergency is lessened by the adoption of twin-screws with independent engines. 3d, in the undamaged condition, sail is not essential to the safety of a steamer at sea. This points rather to a more universal reduction of sail area, but let it be clearly understood, not to the subversion of seamanship. Seamanship will remain as an art lifted to a much higher scientific plane, and therefore more difficult of acquirement than formerly. Its character as an art, involving prompt special judgment and high personal qualities, will suffer no abatement, as will appear in the course of this paper.

After making due allowance for the life-time of the wooden relics, shall we confine our knowledge of sails and sailing to the possibilities of a long vessel with only two-thirds sail power, bark-rigged and without head booms, or what shall we recognize of the old quarter-deck seamanship and how shall we apply it? This is the rock on which most opinions split, and is therefore the most difficult point to decide at the present time. I *have been* inclined to generalize with the iconoclasts, but there are strong arguments against me.

A few minutes' consideration shows that the inquiry must be answered under two heads, viz. *Theory*, or that which we would require an officer to know against all the possibilities of service, and *Practice*, or that which we would accept as worthy an expenditure of time and practical effort, as a matter of habitual routine, or otherwise, on board our vessels.

The existing officer has the theory already, and is the better for it, if he is not content to rest there. But the Naval Cadet is for the new Navy; in his future practice his dependence on sail will be in a minor degree only; his education being scientific, he will regard as a nuisance any undue sail power, which he will know is at the expense of true efficiency, for displacement tonnage, usurped by one quality, must be sacrificed by another. Having tried to show that I have given my subject some serious consideration, opinions may be advanced.

1. So long as the wooden relics remain in service, officers attached to them must be competent to fill their stations, with respect to seamanship as with all other branches; that is, line officers must be able to sail them as sailing ships if necessary, as in the case of engines disabled.

2. Whatever the rig of new vessel to which a line officer may be ordered, he must be able to utilize her sail power, in whole or in part, to all possible advantage, *and from the moment that he sets his foot on board.*

In respect to the theoretical knowledge of seamanship involved, these two assertions are not so widely separated as some officers seem to imagine. Any officer who is competent to take the deck of a square-rigged sailing vessel, or, which amounts to the same thing, one of our relics under sail, is competent for that duty on board all of the new war vessels, whatever their rigs, because sail management of the old type is fundamental for the new types. But an officer may be competent in the same sense on board some of the new vessels, and yet be unfit for service on board others, or on board a ship-rigged vessel. I am inclined to believe, therefore, that in demanding without qualification that we shall stop teaching the working of sailing ships, officers are going farther than they intend, because compliance with their demand would force us to abandon the rational method of teaching by fundamental principles, and compel us to adopt the less comprehensive one of special cases. By the former, we reduce the study to its smallest compass by covering all applications in a single existing type and thus prepare in advance for all types; by the latter, we must await the appearance of special types in order to prepare many officers for service on board them. It seems clear to my mind that to be generally useful hereafter, young officers must proceed from fundamental principles in all branches, seamanship being no exception. With the multiplication of types and the prospect of greatly diversified duties, a life-time of mere experience, as one will be likely to find it, will not cover the necessary ground.

Again, in teaching seamanship we should be influenced beyond the strict demands of every-day practice, as in respect to a liberal education in any other branch of study. Instruction in navigation is not confined to a knowledge of getting a ship from port to port, nor in the steam engine, to questions apart from the principles of mechanism. The education of a lawyer is not confined to the practice of modern law, nor that of a doctor to the specialties of his future practice, which would make him more or less a quack; but each is expected to become widely informed in both past and present practice, in order to amplify his scope of future study and conception. But there are *practical* reasons of moment for continuing to teach to young line officers the principles of management under sail alone. A naval officer's field of action includes instrumentalities and operations outside his own ship and service. We line officers, even in our character of seamen, have a wide range of duty. We serve in the Coast Survey on board sailing vessels as well as steamers; prepare sailing, coasting and harbor charts at the Hydrographic Office for all classes of vessels; also meteorological charts chiefly for sailing vessels; advise sailing-masters as to routes, weather conditions, etc.; in the

Branch Hydrographic Offices, come in direct communication with sailing-masters and discuss with them questions relating to sailing vessels; are liable to be called on to decide as to the location of lighthouses, lightships, buoys and beacons, which involves a knowledge of the practice of sailing vessels. We may at any time be ordered to serve on boards to investigate collisions involving sailing vessels. We must be ready to predict or to prescribe the routes of sailing vessels, or to convoy them in time of war. To convoy them we must comprehend their limitations, in order to give them every advantage. Our immense coasting trade looks to us for protection. We must avoid collision with sailing vessels by day and by night: they have the right of way, and we must be able to prejudge their manœuvres, which, at night, is sometimes possible only to a sailor. Our nautical world is peopled to no small degree by the seamen of sailing vessels, amongst whom our influence is slowly but constantly extending, and with whom we have a common phraseology. In time of war it is the sailing vessel which will fall the easiest prize, and the charge of which will be assigned to junior officers. Finally, if we are to read critically the naval history of our own and other countries, and investigate the tactics of great naval battles of the past, we must understand, at least in a general way, the common evolutions of sailing ships.

More might be said to the point, but enough has been said, if it has been shown that there is still some reason in teaching the principles of management under sail; and it may as well be admitted that these are very easy principles indeed to young officers highly trained in mathematical and mechanical principles and applications. If these officers are weak in practice, it is chiefly from lack of practice. At present they are under the disadvantage of serving on board full-rigged ships, where practice under sail is so scant that they have little opportunity to become more than theorists. On board the new ships, older officers must look to their laurels, for the accurate and fresh knowledge of the young officers will then have fuller play in various directions.

What has been said thus far relates chiefly to the *knowledge* of management under sail and the acquirement of that knowledge through fundamentals. The extent to which we may properly carry the application into our practice on shipboard is a matter of much narrower limits. It may be stated, generally, that the limits of practice should be the necessities of current service, aiming at efficiency in a fighting sense, leaving to theory the possibilities of remote service. We must make up our minds, without wringing our hands, that a few years hence our officers will have ceased to be practical sailors as measured by past standards, but then the urgency will have abated. They will be none the less seamen, however. Up to the sailing capabilities of the new ships, officers must be eminently practical; beyond that, a well-grounded theoretical knowledge of sail must suffice. As time advances and development progresses, even theory will suffer contraction, until, finally, all but the most general principles will be abandoned to the investigator.

It will be especially necessary, in accommodating ourselves to the new Navy, to constantly bear in mind the object of its existence—to understand that whatever practice promotes fighting efficiency is good, and that whatever defeats it, whether directly or indirectly, is bad. Since sails and spars now contribute to that end only indirectly, an attempt to measure discipline or strength of organization, or to compare the efficiency of one ship with that of another, by displays aloft, will be futile. Handling sails is still necessary, but should be prosecuted with a view to utility alone, not display. Sail drill with a watch, therefore, might be deemed more important than with all hands. Spar drills should come in as a part of clearing ship for action, and should include provision for launching them overboard, and buoying and anchoring them, or rigging them as defensive booms. Spars should or should not be struck, according to circumstances. Handling spars having been established in its proper relation, *i. e.* to clearing ship for action, the practice gained has its secondary applications in sending down spars for chase or passage against head winds, or for repair. This is not to lose seamanship; it is simply a turn that seamanship should take. The military character of a man-of-war has very much enhanced in relation to its purely nautical character, and seamanship must bend in that direction to contribute squarely to the end in view. To say that seamanship has had its day, or that in pursuing a certain line of advisable departure we are abandoning seamanship, is to play on a word, or to declare that in future vessels will be automatic. It may be said, to digress somewhat, that extremists, diametrically separated, seem to come together in perverting the present meaning of the terms practice, practical officer, practical experience, and the like. The very conservative officer believes we are not practical unless we adhere to much of the old-fashioned practice, while the staunch theorist decries the importance of practice, because he also associates the idea with old-fashioned practice. We may meet both of these views, by claiming, that an officer is of value to the service, just in proportion as he can apply intelligently and readily the principles which he is expected to know; but it should be borne in mind that this relates to live principles in many directions, old or new as the case may be, not alone to serving guns, quarter-deck seamanship, or boat duty.

The argument most commonly advanced in favor of continuing, what many officers regard as a superabundance of exercise aloft, is, that it imparts a cat-like or seamanlike activity to the men. If cat-like activity is necessary in moderate drill aloft, military drills, pulling in boats, making signals, managing torpedoes and ammunition, caring for the ship, etc., and cannot be obtained directly from these duties, then it may be obtained from such extra drills aloft as the rig of the ship affords; otherwise, fancy drills aloft constitute a misdirected and time-consuming effort. Cat-like activity is overestimated; it has had much to do with slovenly results at quarters and in military exercises, by perpetuating the scurry which is out of place in the present day and is deplored by thoughtful officers. If we wish to impart a reasonable degree of suppleness and fail through the medium of efficiency drills, it might be well to substitute for fancy drills aloft some system of gymnastic exercises, culminating in tournament exhibitions, as less burdensome to the men. The apparatus might be light, portable, and inexpensive. Many of the Naval Academy graduates are competent to instruct in general gymnastics, boxing, fencing, swimming, and wrestling. Gymnastics, if adopted, should be obligatory.

To avoid extending this paper unnecessarily, I will confine my remarks by taking up topics very much as they occur in our standard work on seamanship. Nearly all line officers have that work, and therefore a ready reference is provided them for comparison. My object is not to criticise that work, but to use it as a convenience, because it represents the needs of the service up to 1883. After having availed myself of the table of contents of that work, so far as they suggest remark, I will pass to topics not treated therein, but which now deeply concern the seaman. It will not be possible for me to cover the whole field of official interest, however.

Chapter I.—*The Ship and Definitions* is of but little value in 1889. It is little more than a list of names of parts of the ship of the old type. What is to be said of the ship itself in this paper will come later.

Chapter II.—*The Compass.*—*The Lead.*—*The Log.*—An officer who has made the theory of navigation his specialty, lately said that from the turn naval affairs were taking, about all of navigation was becoming seamanship. Doubtless he did not intend to be taken strictly at his word, but there is no inconsiderable basis for his remark as applied to the practice of the United States Naval Service, for with us every line officer is indifferently a seaman or a navigator. The compass has always been balanced between navigation and seamanship, and with the lead and log may fairly be claimed by one or the other. In the same way, at least in our own service, where we are our own pilots, pilotage has become as much a matter of duty for the seaman as the navigator. The commanding officer is the pilot, and, beyond the question of convenience, he cares but little whether he has the assistance of the officer of the deck or the navigator. The latter has his position simply because he comes next after the executive in seniority. I lately proposed that lectures on piloting be given in the Department of Seamanship of the Naval Academy; this was at once agreed to by the Superintendent of the Academy and the head of the Department of Navigation. An attempt will be made later to show the great importance that shipbuilding and naval architecture have assumed for the seaman. The importance suggests such a considerable treatment of those subjects for his benefit that a separate work devoted to them becomes necessary. As no place can be found in that work for what remains of our former seamanship, the latter, as modified by development, might properly be embraced in a work with pilotage as one feature. Pilotage would find at least as appropriate a lodgment there, as in a book devoted to navigation. At all events, it will require at least two works to include complete instruction in seamanship. Chapter II is good so far as it goes, but, with high speeds, more attention must be given to speed-indicators and to navigational sounding machines for use with wire, or some equivalent device for sounding without stopping the vessel. It is hoped that out of the swim of modern nautical change will emerge the practice of reading the compass exclusively by degrees. At a speed of 16 miles per hour a vessel steams 384 miles per day. The departure for 1° and 384 miles is 6.7 miles—a sufficient argument for setting the course of fast vessels to the nearest degree.

Chapters III to VI inclusive.—*Rope.*—*Knotting and Splicing.*—*Blocks.*—*Tackles.*—So far as I feel safe in predicting development, these subjects will retain much of their present interest. Details will change as experience may dictate—in some types more than others—but no radical change throughout the whole service in the direction of immediate tearing down suggests itself. Purchasing weights has left its groove with the advent of new rigs and the consequent departure of settled conditions, so theory comes to the front for stronger recognition. Rope and blocks are gradually making way for metal gearing wherever rigidity of movement is admissible, as in hoisting apparatus, boat davits, derricks, etc. It is believed that this tendency will serve to remind line officers, more strongly than any expressed opinion, that as a class they must give more study to the science of mechanism. Since the duty of engineers lies almost wholly with machinery, and their title implies that fact, it is not questioned that they should study that science, but it seems to be not generally recognized that the line officer's duties now include a wider *range* of mechanism than the engineer's. For example I may mention the instruments of precision relating to astronomy, navigation, meteorology, electricity, and ordnance; the mechanism of small arms, great guns, torpedoes, rapid-firing guns, machine guns, dynamite guns, steering apparatus, and deep-sea exploring apparatus; the machinery for the manufacture of great guns and their mounts, for the manufacture of rigging and other articles of equipment, and, finally, the steam engine, in degree second only to that of the engineer himself. Yet this enumeration does not fully state the case. It is too much the habit of line officers, as a class, to depend on their fine general education and varied experience for a knowledge of mechanism. The field is becoming too broad for that, and again we come to the study of fundamental principles. We must start out from the *elements* of mechanism in order to include, understandingly, all the applications. Herein lies one of the urgent necessities of the hour. For some years past our naval cadets have studied the elements of mechanism, and have learnt to make and read mechanical drawings and work from them. The cadets take a practical course in the pattern shop, foundry, boiler shop, machine shop, engine-room, boiler-room, and steam launches. They are also associated with mechanism in the Departments of Seamanship, Ordnance and Gunnery, Philosophy and Chemistry, and Applied Mathematics. When we reflect that a little practice counts for much with highly trained minds, and that the cadets have a great deal of practice, we must come to the conclusion that if older graduates would not suffer in comparison, they must make headway on the line which has been pointed out.

Chapter VII.—*Masting.— The Rudder.*—This chapter relates chiefly to wooden spars, except that an iron lower mast is described. A considerable part of the chapter retains its value, but, as a whole, it is not up to date, as might be supposed from the date of imprint. Heavier masts and yards will be made of steel hereafter, but the smaller ones may be made of wood. Inside calibers are limited to the size of a boy, who must crawl inside to help with the riveting. Tops, lower crosstrees and tresseltrees, caps and cheek-pieces for heavy masts will be made of steel. In fact, steel will be used wherever it can be worked to save weight. Weight is now more often a question than room. The wooden relics are all that lend much interest to head booms. Spars and derricks should be described as elementary appliances for general use; any application to a special case will then become a simpler matter of explanation. Seamanship books have always been written in a more or less fragmentary manner, as a detail of the experience of many officers, hence the diffuseness in their treatment of the subject. Chapter VII has but little to say about the rudder, but that appliance now comes in for a great deal of attention. Quick turning is recognized as so important a quality of men-of-war, that rudder areas have been greatly increased with the invention of suitable steam, hydraulic or equivalent devices for operating them quickly. *Quick* full-helm action is a large factor in reducing the tactical diameter. Rocker keels, formed by cutting away the forward and after deadwoods, contribute to quick turning, while, of late, the shape and placing of the rudder has undergone improvement for twin-screw vessels, and all but the smallest men-of-war will have twin screws; in fact, we may come to triple screws before long. The lines of the new form of rudder, when the helm is amidships, are a continuation of the lines of the afterbody of the vessel. The rudder is hung somewhat like the equipoise rudder, and is placed so far forward that the forward edge projects into the spandrel between the propeller and the hull when the helm is over. This insures much better helm action in backing.

Chapters VIII to X inclusive.—*Standing Rigging.—Rigging Ship.—Sails.*—Naturally, these chapters are rather redundant for the needs of the new vessels; they refer more to the relics, but contain the essence of present needs. The fitting of standing rigging will be much simpler than it has been. Dead-eyes and laniards must give way to rigging-screws fitted with pelican hooks for immediate tripping. Top space is too valuable for working machine guns to be occupied by the eyes of the rigging, so lower shrouds and stays will set up to lugs below the top. For the same reason we may expect to find instances of pole-lowermasts in battle-ships, and of topmasts and lowermasts in one piece, or of topmasts telescoping within the lowermasts. Owing to the ample beam of the new ships conjoined with short masts, channels are obsolete and all rigging will set up inboard. Tucked eye-splices are still our resort with wire rigging, the latest having considerable drift away from the thimble to accommodate a flat seizing. The rope is tucked twice, then halved and tucked once, then quartered and tucked once. This, though strong, is difficult to make, and it is hoped that some compact clamp may be adopted. Open thimbles sometimes collapse, one leg projecting beyond its fellow and cutting the rope. It will prove a great convenience if standing jeer-blocks continue to form part of lower slings. The chief departure from old equipment will be in the *structure* of yards, masts, tops, derricks, boat fittings, hoisting and weighing apparatus, etc. There is yet no important change in respect to sail other than bringing the head sails inboard, reduction of sail area, and abandonment of studding sails.

Chapter XI.—*Purchasing Weights.*—This subject has already been touched. In any new work on seamanship, the yard, stay, triatic stay, pendants, slings, etc., should first be discussed as elementary appliances. That is done to some extent in this chapter, but not so completely as would probably have been the case had the authors written in this our day of many types. It should be understood, however, that simple treatment of a subject for shipboard use is often defeated by the necessity for giving the customary stages and orders by which operations are conducted in an orderly manner and by concerted action. Apart from the matter of simplicity of treatment, an officer fully informed on this chapter would not be at a loss in purchasing weights with tackles on board any of the new vessels.

Chapter XII.—*Stowage and Supply.*—The requirements of the new ships have left this chapter nearly obsolete, stowage having assumed much greater importance in relation to buoyancy and stability. Attention was formerly given to stowage as connected with stability—sometimes with misapplication—but not in all the aspects in which it is now considered. Stowage now has reference to buoyancy in the damaged condition; to stability both in the intact and the damaged condition, and to the behavior of the vessel among waves. Heavy articles are stowed away from the ends of the vessel in the middle body, to decrease the moment of inertia of the ship about a transverse axis and shorten the pitching period, in order that the vessel may tend to follow the motion of the heavier waves, and thus be drier. Heavy ammunition is about equally divided between the forward and the after body, or still further concentrated by being placed wholly in a central position, near the boilers. The latter may have to be discontinued because of the effect on the powder. The ammunition is stowed near the midship line, for safety from shot and torpedoes. Generally, however, heavy articles are stowed in the wings, to increase the moment of inertia of the ship about a longitudinal axis, and thus increase the rolling period, it having been found that ships with long periods are the steadiest in a seaway—at least under conditions most likely to occur. More will be said of this later. Coal is stowed in the wings, both above and below the protective deck. The latter should generally be used first, carrying that above the deck as a protection to both buoyancy and stability in the event of damage, to prevent the entrance of shot into the vitals of the ship, and to absorb the energy of the explosion of shells occurring within the bunkers. With coal above the protective deck, the volume of water, that can enter the ship in a damaged compartment thus situated, is restricted to the difference between the volume of the compartment and the volume of the coal. In this sense the coal acts as a safeguard to buoyancy and stability. If the coal above the deck stow low with respect to the center of gravity of the ship, the expendituture of coal from below the protective deck, while having the effect of raising the center of gravity and thus decreasing the metacentric height, may also increase the moment of inertia and add to steadiness. Light and bulky articles, especially articles impervious to water, will be stowed above the protective deck, to exclude water in the same way as coal, and the tendency will be to assemble stores of a single kind in one compartment. In these matters the question of convenience and of accessibility in case of emergency will have weight, of course. Stowage has now assumed too important an aspect to be treated as a study disconnected from the technical qualities of the vessel. The considerations which enter into the question must be understood.

Chapter XIII.—*Boats.*—Pulling and sailing boats will continue in use, and the principles of their management will not change. Details of their structure may change, or, at least, it is hoped they will, for many of our pulling boats are not well adapted to their purpose. The handle of the oar must be swung so close to the knee that the oarsman can get no swing, and appears to sit bolt upright, as if taking no interest in his work. Steam launches will be faster and lighter, and more used than ever. It will perhaps be the rule to have one of the whale-boats provided with steam power. Whether the ship's steam launches or special second-class torpedo-boats will be the dependence for independent torpedo attack is an open question. As a rule, all boats will stow inboard, to escape the blast of gun discharges. The heavier boats, especially on board battle ships and other large ships, will stow on skid-beams. Davits will doubtless be continued in use to a considerable extent, especially for light boats and for the boats of small vessels, but derricks will be used for heavy boats, and possibly for nearly all boats in the course of time. It is not unlikely that submarine torpedo-boats will be a feature of future equipment. At any rate, submarine boats will be used in the service at large. The problem of their successful operation is nearly solved, and the study of the conditions of their operation now presents itself seriously to the service, since the Navy Department has invited designs and bids for a boat of this character.

Perhaps a few words in digression may be said about mechanical devices for lowering boats in a seaway. Nearly every graduate of the Naval Academy of inventive tendencies, including myself, has invented one or more of these devices, or has tried to invent one or more. Some of them are of great ingenuity and of more or less theoretical excellence. That they come and go in varying procession with outside inventions of the same class points to a deep-rooted distrust of them, if not to doubt as to the utility of any metal tripping device whatever, which must be operated from within the boat by a blue-jacket. The cause for this feeling, if it exists, may lie in the fact that these devices are used only in dangerous and rare emergencies, the character of which so abnormally excites the sympathies of blue-jackets that they can be less trusted than at any other time to operate mechanism properly. Yet the mechanism in question must be operated at a moment so precise that a slight non-observance is likely to lead to greater disaster than that which it is the desire to avert. Again, the mechanism is one of various pivots and long connections—a kind which, when exposed to weather at sea, requires daily care and testing to provide for these remote emergencies. Theoretically the devices get this attention, but practically they do not, nor do the men get enough practice with them to beget confidence, not to speak of the operator having his station changed. It is suggested, in this connection, that some one strike out in new lines—which suggestion may be deemed to bring this digression into line as progressive seamanship.

Chapters XIV and XV.—*Ground Tackle.—Steam Capstans.*—There is a tendency to modify the shape of anchors to increase the holding power and afford compact stowage and easy manipulation. The favorite shapes are those in which both flukes bite at the same time. In some cases the anchor-bed is recessed in the bow in such a way that the anchor is hove directly to its bed without catting or fishing. Rotating derricks are used also, especially for sheet anchors. Steam weighing apparatus, or its equivalent, is becoming universal, and is said to be generally lighter in the latest vessels abroad than we find it in our own new vessels—an important point, since it is not desirable to add to the heavy weights at the extremities of the vessel. It has been attempted abroad to use wire hawsers in lieu of chain cables, but apparently without enough success to warrant their general adoption. My own experience in a different field shows that it is strictly essential in any such use of wire rope—at least in the smaller sizes, and presumably in the larger sizes—that it be kept constantly taut to prevent kinking. When slacked, wire rope tends to take the form of the convolutions which it has had when wound upon its reel or drum, and there is danger of kinking when it is again hauled taut. Kinks cannot be straightened out, and they so much impair the strength of the rope that it becomes untrustworthy for its original purpose. I am at a loss to understand, therefore, how wire rope could be used for hawser cables, without some automatic device for taking through slack. For sheet cables, the case would be somewhat different. These are used only on occasions when they would be continuously under tension, but they might kink in fouls caused by the swinging of the vessel.

Chapters XVI and XVII.—*Mooring.—Carrying out Anchors by Boats.*—These chapters contain so much information of continued application that no comparison, within the bounds of my purpose, suggests itself.

Chapters XVIII and XIX.—*Organization.—Duties of Midshipmen.*—Perhaps no known organization has ever been more perfectly adapted to complicated needs, as they were understood, than that of men-of-war of recent times. Long and varied experience by many men of executive ability, with vessels of practically the same type, resulted in a form of internal organization which met with general approval and adoption. But it is well to emphasize the fact that although it was afterwards adapted to full-rigged steamers, it was originally made to conform to the needs of that special type of vessel in which there was entire dependence on sail for propulsion, and in which the management of sail may be said to have won the day as often as guns. Sail has now become a weak auxiliary, only of use for cruising purposes, and the urgency for asserting the military character of our organization is great. It is probable, therefore, that the old form has reached its elastic limit in the wooden relics.

The organization which, of late years, has been prescribed by the Navy Department, on blank forms issued to each vessel, is the result of researches into the bills of crack ships, extending over many years, fortified by the personal suggestions of officers of acknowledged executive talent. That plan of organization descends from a nautical plane as a basis, to a military plane as an extension; but it has been questioned if the reverse plan would not secure greater efficiency on board some, if not all, of the new vessels. If we must still use the nautical basis, uniformity throughout the service can be obtained in the future by dividing the crew according to parts of the hull. Each ship might then have the same number of watch divisions and subdivisions. It is probable, since batteries vary as well as masts, that the greatest possible uniformity can be thus obtained. These department forms may not be issued to the new vessels, but it is hoped, in view of the emergency of change, which is in prospect for us in the new naval constructions and methods, that the fullest latitude will be allowed commanding officers in working out their own cure in respect to internal organization. If a past generation of officers was capable of perfecting an organization for one type of ship, it is probable that the highly educated officers of this generation will not be found less adaptive for other types.

At the present time but one idea seems to pervade this country with respect to the Navy, which is to build and arm ships. The idea that these vessels, afloat and armed, will prove more valuable to an enemy than to ourselves, unless well organized and fought, has not yet developed to the proportions of a public question. Everybody knows that mere assemblages of armed men on shore are powerless against a much smaller number of men properly organized, yet few seem to realize that a very similar principle applies to ships. The military character of the ship and the service, which is by far the highest character, because it is the only warrant for the existence of the service, does not seem to be appreciated in its proper relation. The ship as a fine structure and the officers as fine fellows are actually of no value to the country, in a naval aspect, excepting so far as they contribute to the fighting efficiency of the service. This remark is not intended to apply to any particular channel of effort; any effort whatever, in the right direction, is better than any other effort in the wrong direction.

Rear-Admiral Luce has lately written on the relation of public policy to naval organization, which in turn has relation to internal organization; and it is probable that many officers, conjointly with myself, have expressed their opinions, relative to internal organization and ratings of men, to the Board recently in session at the Navy Department to consider the question of ratings. Ratings as they have descended to us are as bad as can well be conceived for our future needs, and thorough efficiency is not to be had with them; but that question embraces too many details to be considered here.

Two features of the British Naval Service, bearing on thoroughness of organization and effort, might be introduced into our service with benefit. First, a service motto to prick our consciences in moments of laxity and to hold our object rigidly in view. The British service motto signifies "*We are always ready.*" Second, continual insistance on the necessity of forming quickly the habit of command; that is, of commanding men. In the United States Naval Service, to a greater or less extent, an officer is expected to drift into this habit with the growth of experience, while in the British service he is encouraged or required to set about the formation of the habit with definite intention from the outset of his naval career. The manner of giving orders has much to do with the case, so I will check my admiration for younger officers long enough to say that, as a class, but with notable exceptions, they are somewhat lacking in the quality under discussion, and are not likely to make rapid progress until they improve their method of giving orders. Some advice on this point, delivered in the hope of fructification, may be tolerated.

In respect to intonation, orders should be given as simply and directly as possible—without affected mannerism. To make a display of the voice is puerile. Some officers, it is true, sing their evolutionary orders effectively by making it evident that their object is simply to gain greater range of audibility; but when an officer adopts that style for style only, it impresses one with the belief that he leans towards the utterance rather than the execution of his orders.

In a general sense, orders may be divided into two classes. First, evolutionary and military orders, or orders demanding prompt, *concerted* action; as, Let fall! Hoist away! Shorten sail! Order arms! Orders of this class should be given in a sharp, mandatory tone, but with such occasional modulation that the men will regard themselves as addressed specifically and not by rote. Second, orders conveying a simple direction of a non-evolutionary or non-military character; as, Starboard the helm! Let go the anchor! Ease off the jib-sheet! Sweep down the deck! Such orders should be given with sufficient spirit, in a business-like way; but never with the peculiar emphasis of a military order. The severe, mandatory tone so often used in giving simple directions to one or two perfectly acquiescent men is vexatious, and should not continue.

Several years ago a lieutenant, when asked to account for his successful and pleasant service under the command of an exceptionally strict officer, replied that it was because he had always followed up his own orders by knowing that they were obeyed. "A word to the wise is sufficient."

Chapters XX to XXXIV inclusive, except Chapter XXI.—*Port Drills and Evolutions.—Getting under Way under Sail.—Making aud Taking in Sail.—Working to Windward.—Wind Baffling.—Heaving-to.—Reefing.—Law of Storms.—In a Gale.—Parting Rigging.—Losing Spars.—Shifting Sails and Spars.—Coming to Anchor.—Handling Fore and Afters.*—With respect to these chapters it is not necessary to say more than has been already said in the first part of this paper; to go more into details would only serve to consume time. It will be apparent to all that the matter given in the book refers to a far greater extent to the wooden vessels than to the new ships; yet there is much information of general application. The law of storms is known to all our line officers, from the highest to the lowest. I will repeat that my object in referring to our work on seamanship is merely to have a basis for comparison.

Chapter XXI.—*Rules of the Road.*—Rules of the road are ready-made, and no independent action respecting them is permitted unless it be the abstract one of suggestion. Various devices and systems of lights have been proposed as substitutes for those now in use, with a view to abate the danger of collision afloat. Most of these, if adopted, would only complicate the situation and thus lead to greater disaster. However simple the present system may appear to educated minds, it is nevertheless so confusing in some of its practical phases to some other nautical minds that it often fails of its object through this cause. To oblige the latter class, from which we must expect the greatest failure in the aggregate, to wrestle with more intricate combinations will add to present danger. The danger of collision is greatest when vessels suddenly heave in sight at close quarters, when there is the least time for studying combinations on which to base correct judgment. Effort should therefore be directed towards simplification. Doubtless such considerations as these have prevented the adoption of new systems.

Chapter XXXV.—*Handling Vessels under Steam.*—This chapter is modern, and embraces much more valuable information to the point than I have been able to find in any other work on seamanship, but the treatment will doubtless be different in future works. Some examples of steering mechanism are given, but nothing concerning hydraulic mechanism. Those parts relating to turning effects of the screw, especially of twin-screws, and the turning power of ships, point the way to lines of study daily growing more important to the man-of-war seaman than matters relating to sails. Here we must go to fundamental principles again; it is not enough to know the effects, we must know more about causes. In considering drift-angle and kick, for instance, we must know what impulses conspire to produce kick. These subjects lead up to naval tactics under steam, a branch of our profession which is yet in an unsettled state no system having met with much favor remote from the locality of its author. At the Naval Academy the general subject of handling vessels under steam will begin at the resistance of fluids, and will continue through surface disturbance, the action of propellers, simple and as effected by the features of the ship's resistance, rudder pressures, and the phenomena of turning a ship. In addition, the refinements involved in these several divisions of the subject will be taught to advanced sections. Young officers who compass that course, when it shall have been completely established, will not be likely to regard the handling of steamers as involving mysterious movements or expect unaccountable eccentricities in moments of emergency. The possible advantage to men-of-war of high speed and turning power, especially in ramming, is admitted to be very great, and even slight advantage may be vital; therefore the investigation of principles has its value in preparing officers to discover and improve advantages, or, at least, to know where they might lose them through neglect. So many of our officers have read up this subject that the importance of studying it as indicated will hardly be questioned.

Chapter XXXVI.—*Getting Ashore.—Leaking.*—This chapter relates chiefly to expedients for getting afloat, repairing leaks and to seamanlike procedure, and embraces the teachings of much valuable experience. It is unnecessary to say that any information which serves the purpose of this chapter will always be acceptable to seamen. Anything that I may have to say regarding grounding and leakage will come in later.

After this chapter comes a chapter on the Life-Saving Service of the United States, of undoubted value, and then follow certain appendices relating to rope-making, marline-spike seamanship, management of boats in a surf, miscellaneous routine, clubbing, backing and filling, tending ship, fire-booms, turning experiments, speed and steering trials, etc., some of too much value to be questioned, while as to others my remarks already made are sufficient. I will now abandon our seamanship work as a reference, and discuss matters independently of it.

It must be apparent to many of those who have reflected on the bearing which naval development will have upon the duties of officers, that lines of study are now forced upon the line officer, the necessity for which has not been generally recognized heretofore in our service. The attention of the line officer as a seaman is now directed mainly to the hull and that which pertains more or less intimately thereto; and we find that the diversity of structure, fitting and equipment is great, the character of risks varied and novel, and the responsibility immense. With the new vessel, directed by intelligence and knowledge, great feats may be performed; but, on the other hand, great blunders may be made through ignorance or misconception. Even very limited reading indicates that we must have a far more accurate knowledge of our new ships, their structure, strength, qualities, behavior, management and possibilities, than we had of the wooden ships; and this is true not only as to individual ships, but as to ships relatively to one another. Theory, therefore, is more nearly indispensable to complete fitness than formerly.

Theory must begin with a study of types, in a general, historical sense as well as specially. If this must be pursued individually, the only recourse is wide and continued reading. Since this may be more or less discouraging, because of non-availability of the literature of the subject, it is to be hoped that post-graduate instruction will be afforded as a relief. In any event, the field is too wide and too much filled with detail to be covered without persistent reading and comparison. Officers must become saturated, so to speak, with a knowledge of types, in order to comprehend on all occasions the value of their own force relative to another force. From types we must go to structure, general and special. We must know how ships are constructed, arranged, and provided with safeguards and expedients, and, at least in a general way, the magnitude of the strains, local and structural, to which they may be subjected, and their capability of resisting them. We must also have a knowledge of theory and applications pertaining to the buoyancy, stability and management of ships, to their behavior among waves and under other and varied circumstances. All this, let it be understood, in a higher degree than heretofore, and strictly as demanded by recent development.

If there are any who fear the abandonment of sail and the decadence of top and marline-spike seamanship, because of some supposed influence in degrading the functions of the line officer, to them a word may be said.

I am only giving utterance to well-recognized truisms when I say that there is no higher study which may properly come under the term seamanship than that which investigates the qualities, behavior and management of vessels, and no higher practice pertaining to shipboard than management of the vessel, the control of her behavior, and, in general, the use of her qualities. It is here that we find play for intellectual effort, combined with the rare and high personal qualities that lead to great naval achievements, followed by national gratitude and reward. In respect to this phase of seamanship, we suffer in nowise by the abandonment of sail. In the new Navy, the requisites for success are somewhat different from what has been demanded in the past, but they are distinctly on a higher plane, and there is a broader field for the exhibition of practical excellence. It is no longer possible to compass the range of naval seamanship as one learns a trade. A second mate, by virtue of his seamanship alone, cannot again be transmuted into a naval officer. The naval seaman has much to gain and nothing to lose in pride of position by encouraging development: he needs only to see the situation and to prepare himself for it.

I will now proceed to justify my belief by amplifying on the preceding statements, but only so far as to show in some degree the interest of the subjects presented: it should be understood that I neither presume to teach principles nor to do more than trench on the ground to be covered. I am also aware that my paper will contain nothing new to a fair proportion of officers.

A characteristic of modern naval architecture is the nice apportionment of weight displacement among the several qualities aimed at in the design of the vessel. To get many desirable qualities in high degree in a single vessel is possible only with a displacement so great as to sacrifice handiness and light draft, not to speak of the risk of concentrating, in a single fighting unit, an excessive proportion of the national power of offense and defense. This has forced upon us a multiplicity of types, each type having in a high degree those qualities which, according to one interpretation or another, are deemed most necessary to the performance of the special service for which the type is intended; and these qualities are attained always at the expense of other qualities deemed less essential to that service. For instance, the coast-defense vessel absorbs a high percentage of displacement for armor and guns at the expense of speed and endurance of supplies. In fact, these latter are reduced so low in the scale that thick armor and heavy guns are secured, with comparatively light draft and moderate load displacement. Again, the unarmored cruiser sacrifices weight of armament and dispenses with armor, reserving thereby a certain amount of displacement, which is apportioned to high speed, coal or cruising endurance, and more or less sail power. When high speed is reached, a small increase of speed can be gained only at a comparatively great expense of weight displacement. Since the attainment of qualities is not broadly optional, the seaman, however skillful he may be in the use of qualities, is hardly in a position to compare types and criticise special designs intelligently, or to insist on special qualities, unless he has some knowledge of the restrictions which bind the naval architect. The day when one class of vessels was simply a modification of another class of the same type, in structure and qualities, and when the qualities of one ship were commonly prejudged from those of other ships already built and tried, has given way to a period of costly and novel constructions, whose qualities must be foretold, in large part, by calculation.

In the various types of the later war vessels there are certain *general* structural features common to all, viz. metal construction, water-tight subdivision, water-tight or protective decks, draining and ventilating systems, and a variety of mechanical devices to replace rope. In structural *details*, however, there is great diversity, to support armor, provide for the installation of guns, torpedoes, engines and boilers ; to arrange for ammunition supply, stowing, berthing, draining, pumping, lighting, etc., and to guard against the loss of buoyancy and stability through damage at and below the water-line. When we connect all this detail with that of the general structure and of minute water-tight subdivision in every direction, and remember that some ships have as high as 200 compartments, can there be any doubt as to the desirability of line officers having a fundamental knowledge of naval construction, embracing the qualities and working of the metal, the different systems of framing, plating, armoring, strapping, butting, riveting, caulking, and so on, through a long list that has been anticipated in previous remarks? Not only must he know the form and position of details, but also the considerations which move the designer to use one detail or system instead of another. What we want is that an officer shall be able, from a study of drawings and one or two tours of inspection of the ship, to stand in any part of her and picture to himself the exact appearance, condition and arrangement of every other part of her ; and the only hope of reaching this state of things is through fundamental knowledge. Intercepting bulkheads, flats and decks make it difficult to conceive, simply by tours of the hull, the relation which one subdivision of the ship bears to another, but drawings will make it clear at a glance. The intricacies of modern war vessels have become so great that in the British service, at least, two executive officers, one a commander, are detailed for vessels of less displacement than some we are now building. This is done, mainly, to provide suitably for the care and preservation of the various subdivisions of the vessel. The commander has general charge of executive duty under the captain, and the first lieutenant has charge below the upper deck under the commander.

Not only must officers themselves have a knowledge of structure, but they must instruct the men in the same knowledge. With the waning of top seamanship, we will lose the display of reckless courage aloft, but we will have greater intelligence and a wider range of information regarding the hull and its details.

At a less percentage of the total displacement, steel hulls have greater structural strength—*i. e.* strength as a whole—than wooden hulls, but, at the same time, they are locally weaker, and subject to rapid deterioration through causes that but little affect the latter. They demand, therefore, greater care, closer inspection and a more extended knowledge of the conditions and methods of preservation. With care, however, they may be continued in service, incomparably longer than wooden hulls, without extensive repair. Sweating is a characteristic of metal ships that must be guarded against. It is said of the large Italian men-of-war that it is necessary to change their detail of officers frequently, as a health measure, on account of excessive dampness. In regard to corrosion, the outside wetted surface and the intercostal hold-spaces give the most trouble. Cement is used in the bilges and waterways; but while cement, properly applied, is a perfect preservative, it is a source of danger if it loosens and allows the entrance of water between it and the metal. The speed of metal vessels is not only decreased for the time being by fouling of the bottom, but permanently also by the resulting roughness of the plating.

Buoyancy as an independent study is not new to graduates of the Naval Academy, but the recent writings on the buoyancy of ships, embracing the thought and experience of the new period of naval construction, will suggest ideas not likely to occur in general service afloat. In the structure of the wooden ship there was no protection to buoyancy other than that due to the great thickness of frame and double skin: water-tight subdivision was not attainable. In the steel ship, with her thin and more easily penetrable skin, there is greater need for such protection, and, fortunately, it has been effected to a considerable extent, by virtue of the qualities of the metal and the greater structural strength which it affords. But this new phase of construction opens up questions relating to buoyancy not considered in the days of wooden ships. This protection is not complete; it is one of degree only. In certain types of ships it is not even attempted to prevent the entrance of shot into the hull, but simply, by means of water-tight subdivision, occupation of space by water-excluding stores and employment of contractile substance, to so localize and minimize the inroad of water on buoyancy that the probability shall be against the annihilation of the reserve buoyancy by accident or the damage of battle. But damage may be much or little, and the percentage of reserve buoyancy to total floating power varies greatly in vessels, ranging from that of the submarine vessel as a minimum to that of the high-freeboard cruiser as a maximum. Although buoyancy may not be wholly destroyed, yet so small a margin may remain that sinkage can be prevented only by a nice comprehension of the situation to be met. Again, buoyancy may be ample, but by encroachment upon it, stability may be lost unless carefully guarded; speed may be effected, trim altered or draft increased. To know what action to take when buoyancy is at stake, the line officer should be able to comprehend his risks. He should be able to estimate the change of draft, the inroad on reserve buoyancy, and the change of trim which would result from flooding one or more compartments of his vessel; the amount of water that would enter the vessel through any area of damage at any depth in a given time, and the capacity of the pumping system to preserve or restore reserve buoyancy in assumed cases of damage. It may be said generally, however, that no ship has sufficient pumping capacity to constitute in itself a complete protection to buoyancy excepting against ordinary leakage or slight damage. Through a hole sixteen feet below the surface of the water and one square foot in area, sixty tons of water per minute or 3600 tons per hour will enter the ship initially. The chief dependence on the pumping system, in the event of great damage, is in clearing the ship of water after leak-stoppers have been applied. This relation of the pumping system to buoyancy is recognized in the construction of the British ram Polyphemus, a vessel of small reserve buoyancy. She is provided with several hundred tons of detachable ballast, which may be let go at a critical moment. The following are means for the protection of buoyancy, viz. armor, water-tight decks and bulkheads, double bottoms, coffer-dams, water-excluding stores, cork, ordinary coal, patent fuel in rectangular shapes for compact stowage, a contractile substance called cellulose fitted under pressure into water-tight compartments, pumping and draining systems, leak-stoppers of various kinds, hauling down chains, sheet lead to make templates of leaks and the locality of leaks, cement to fother leaks within the vessel, diving apparatus, etc. It is true that this list embraces details readily used by ordinary intelligence, but it is in respect to a comprehension of the character and extent of damage as bearing on the safety of the vessel that the subject of buoyancy invites greater attention than is now given it.

It is probable that the loss of the U. S. monitor Weehawken was due to unenlightenment as to the conditions of flotation of that vessel. She was sunk at her anchors off Charleston during the late war, by water flowing over her decks and down the forward hatchway into the anchor hold. It was blowing a gale at the time, and the forward hatch was open; but the situation, except, perhaps, as to an extra supply of ammunition and coal on board at the time, was not exceptional for that vessel. The nature of the accident, and the unexpected result following so quickly the first signs of danger, lead to the belief that the vessel had far less reserve buoyancy than was imagined by those on board. It can hardly be supposed that a like accident could occur at this day.

As a result of the employment of a variety of types of ships with different heights of freeboard and conditions of service, and subject to different degrees of damage, there has arisen the necessity for a better knowledge of stability. The conditions of stability, affecting the handling of ships in a damaged state, are far more critical than those of buoyancy. A vessel damaged above the protective deck may retain ample buoyancy for flotation in the upright position, and yet have become so crank, through loss of water-line area and the consequent reduction of metacentric height, that an attempt to turn her in a small circle would cause her to capsize. But a vessel in such a condition might be handled in a way to continue serviceable to a fair degree. In future naval battles we may expect that many more vessels will be capsized than sunk. This phase of fighting accident did not exist in the days of wooden ships; it has come with the new types, and the knowledge to prepare for it should form part of the line officer's intellectual equipment.

In the light of the present knowledge of the subject, it is plain that vessels have been lost through ignorance of the conditions of stability rather than careless disregard of them. Investigation of the question received a great impetus by the sinking of the British turreted low-freeboard man-of-war Captain, a vessel provided with large sail power. She had exceptionally good stability up to the angle where her upper deck dipped, when it soon began to fall off so rapidly as to render her unfit for her canvas under circumstances of weather and sea to which cruising made her liable. She was capsized in the Bay of Biscay while under sail, carrying down with her nearly all hands, including her designer, a naval officer. Her loss is monumental as an instance of the temerity of attempting great technical feats without a knowledge of the fundamental principles involved. The loss of the Captain may be said to have settled the question of freeboard as related to stability, but the question of stability in the damaged condition, with respect to types, is viewed so differently among naval architects that, if for no other reason, the naval officer should look carefully into the subject himself. The question hangs chiefly on the probabilities in warfare, and is therefore very much a matter of speculation at present; nor is it likely to be settled, except by disasters of which naval officers must bear the brunt of danger and responsibility. The stability of a vessel changes with the weight which she carries, and with the position of the weight. For ordinary service this concerns the merchant vessel more than the man-of-war, but when warfare is taken into account, the reverse is the case. It is not my intention to touch on principles further than to give at least a slight indication of the importance of the study, but within this limit attention may be called to the several ways in which stability may be affected by water entering a vessel.

1. A compartment may be filled with water which it completely incloses, in which case stability will be affected in about the same manner that it would if the water were replaced by a solid body of equal weight and having its center of gravity in the same place.

2. A compartment may be partially filled by water which it completely incloses. In this case the water is free to alter its form and position with the vessel's rolling motion, and the effect on stability is similar to that of a weight moving about unrestricted within certain limits.

3. A compartment may have water in it in free communication with the sea and at the sea level for all inclinations. In this case the effect is the same as if the vessel were deprived of so much of her volume as is thus occupied by the water. Her weight remaining the same, the vessel must have increased immersion until the additional volume of displacement equals the volume of water in the damaged compartment. Stability is affected; the center of buoyancy and metacenter having a new position.

The primary use of a knowledge of stability to the seaman is not necessarily to make calculations, but rather to distinguish between cases and to interpret aright the technical qualities of the vessel from the graphical and numerical data which will be at his command. The information of greatest value may be stated as follows: Under various conditions of load, the metacentric height or the initial stability; the angle at which the deck is awash; the angle at which the maximum stability is reached and beyond which the righting force diminishes; the angle at which stability vanishes; the effect on stability of adding, removing or shifting weights, and the effect of under-water damage. Officers will be expected from time to time to perform the inclining experiment with the completed ship, to determine the vertical position of the center of gravity.

Officers having a desire to gain a fair knowledge of stability need feel no discouragement on the score of mathematics. Mr. W. H. White, in his *Manual of Naval Architecture*, manages to impart a fair knowledge of stability without going into mathematics beyond a right-angle triangle, but a further resort to mathematics is necessary in treating the refinements of stability.

Sir Edward J. Reed, in his work, *The Stability of Ships*, says: "In this work the author has endeavored to make the earlier chapters intelligible even to those who do not understand mathematics, and in those earlier chapters will be found all that many persons who are concerned with ships require to know. But non-mathematical readers should not be deterred from pressing on with their study of the subject by the occasional intrusion of a sign of integration or other mathematical symbol. The general sense and purpose may often be easily mastered even by those who cannot interpret the mathematical expressions."

A fair knowledge of stability is also essential to an understanding of the conditions of the behavior of ships among waves, which has relation to value as a gun platform, as well as to structural strains and personal comfort. The naval seaman should know under what conditions of sea and stowage his ship will fight to the best advantage, and ride out a gale or make a passage most comfortably and safely. All this may be so nearly predicted in many cases before leaving port that at least the amount of experience necessary to form conclusions is very much narrowed down by the study of theory.

It is only of recent years that the investigation of wave-motion and of the behavior of ships among waves has reached the stage of broad, practical application. Fortunately, the leading principles involved, and their practical bearing on management at sea, have been admirably and simply treated for the benefit of seamen.

The conditions governing the behavior of a ship among waves appear to be:

1. Her period of still-water oscillation—*i. e.* the time occupied by her in making a complete swing when set rolling in still water.

2. The magnitude of the fluid resistance to her motion, a measure of which is afforded by the rapidity with which she is brought to rest after being set rolling in still water.

3. The dimensions and proportions of the ocean waves encountered; also their speed and direction of approach to the ship.

Over the first and second of these conditions the designer of a ship may exercise considerable influence, but not in all cases. This may be explained in a general way as follows:

Synchronism of the still-water rolling period, or natural period, of a ship with the half-wave period produces extreme rolling. It is therefore an object of the designer to give the ship a period which will not synchronize with waves large enough to greatly disturb her, and it has been found by observation and experience that this is best fulfilled by a long period. High metacentric height—*i. e.* great stability—which governs the quality of stiffness, gives a short period and is opposed to steadiness, so increase of period is sought through moderate metacentric height and increase of the moment of inertia, the latter being governed by the disposition of weight with respect to the center of gravity of the ship. Other considerations than rolling also influence the disposition of weights, so the designer is not always at much liberty in the pursuit of steadiness through increase of the moment of inertia; hence some designs show decided pre-eminence over others in this respect. For instance, the British ship Inflexible, with *echeloned* turrets, great weight of side armor and other winged weights, has about twice the metacentric height and about the same rolling period as the Italian ship Duilio, with turrets on the middle line and generally greater concentration of weights amidships.

Although the influence of the designer on the period of a ship may be limited, he has considerable scope in augmenting the fluid resistance, which he exercises chiefly by the use of bilge keels, the effect of which is to quickly extinguish rolling after it has begun. Over this power the seaman has no influence, but he oftentimes has over the moment of inertia—though to a less extent than the designer—by regulating stowage and the expenditure of dead weight. His control is greater, however, over another means of extinguishing roll, that will doubtless be adopted into some of our new vessels. When water within a ship is free to move from side to side, it exercises a more or less powerful effect on the roll, and advantage has been taken of this property to fit athwartship water-chambers above the armored deck of certain ironclads having considerable metacentric heights and comparatively short periods. Into these chambers free water may be introduced at discretion. The seaman may also oftentimes influence the relation between the ship's period and the wave period to bring about a relation favorable to steadiness—an exceedingly important point, in view of the absence of sail in some men-of-war. This may be done by diminishing or increasing speed, or changing the course relatively to the advance of the wave, whereby the *apparent* wave period is lengthened or shortened and synchronism avoided. This involves, of course, some knowledge of wave motion and of observing wave periods, but no more than may be readily acquired.

Although what has been said is very general, it has shown that the behavior of ships is more or less under control when in charge of officers competent to take heed of the governing conditions, and that we are by no means "left in the lurch" by a deprivation of sail.

Both as an educational measure and as an insurance against loss of government property not quickly replaced at any cost, it is to be hoped that every United States man-of-war commissioned hereafter will be amply provided with the graphical and numerical data, which scientific investigation and method of presentment has made available for the naval officer during recent years. This data is copious, and comprehends the qualities of the ship in every direction. Much of it is of greater value in the graphical form. Heretofore we have not done much in this respect. The commanding officer has been provided with a sail and rigging plan and the deck plans of his ship, with a few figures relating to the battery and engine, and but little if any more. They have had nothing concerning the ship's history or qualities, although dozens of semi-annual reports may have been sent in from her from time to time during her several cruises; yet they have had the history of each man who has had a history. I received command of one ship *said* to have a considerable amount of ballast on board, but there was no official word about it. She was a sailing ship, and therefore dependent on water supply from on shore. Her tank capacity, as laid down on the hold plan, was far in excess of the truth. With the exception of the last item, I am speaking of long-established custom—or, perhaps I may say, lack of custom. This should be and doubtless will be changed now, and it is to be hoped that ships will be provided most amply with drawings, both general and special, relating to every quality and feature concerning which information would be either useful or interesting. At least one British shipbuilding firm* issues, for vessels built by it, a book called the "Technical Qualities Book," which embraces graphical and other

* Wm. Denny & Brothers.

data relating to the vessel. This is what we want for our ships—a volume containing the history of the ship, and a detail of her qualities and features in every department. Commanding officers might be supplied with a book comprehending everything available, and other books embracing only non-confidential information might be provided in sufficient number for issue to other officers on board.

The following are some of the graphical curves which are of interest to the seaman as embracing data bearing on the vessel's qualities. The list might be greatly extended.

CURVES RELATING TO THE STRENGTH OF SHIPS.

Curve of buoyancy and curve of weight.—These curves are commonly associated in a single diagram. They represent the distribution of weight and buoyancy and the excess of one over the other at each part of the vessel's length.

Curve of loads, indicating the *unequal* distribution of weight and buoyancy at each part of the vessel's length.

Curve of shearing forces, giving the shearing or racking forces along the length of the vessel considered as a beam and at rest in still water.

Curve of bending moments, giving the bending moments along the length of the vessel considered as a beam and at rest in still water.

Curves of shearing forces and bending moments among waves, giving the maximum shearing force and bending moment which the vessel will have to resist according to calculations based upon two assumed conditions, in which the maximum stresses possible are exerted, viz. when the ship is on the crest of a wave of her own length, and when she is in the hollow of a wave of her own length. The height of the wave is taken at one-fifteenth of its length.

CURVES RELATING TO THE FLOTATION OF SHIPS.

Curves of displacement, giving the displacement of the ship for any mean draft of water.

Curve of tons per inch of immersion, commonly called the *curve of tons per inch*, giving the weight necessary to increase or decrease the draft of the ship one inch when floating at a known draft.

Curve of moment to change trim one inch, giving the longitudinal distance through which it is necessary to move any known weight horizontally to alter trim by one inch, or the weight which it is necessary to move horizontally through any given longitudinal distance to alter trim by one inch.

CURVES RELATING TO THE STABILITY OF SHIPS.

Metacentric diagram.—This commonly contains the *metacentric curve* or *curve of metacenters* and the *curve of centers of buoyancy*, showing the positions of the metacenter and center of buoyancy relative to the water-lines and to each other at any assumed mean drafts. Without the positions of the center of gravity being known, the metacentric curve merely shows the tendency to stability due to the vessel's form ; but by indicating upon the diagram, as is often done, successive positions of the center of gravity also, the statical stability of the vessel at any draft may also be determined with tolerable accuracy from the diagram.

Curve of statical stability, or simply *curve of stability*, gives for stated conditions of lading and damage the righting forces of the vessel at successive angles of heel, the angle of maximum righting force, and the angle at which stability vanishes.

CURVES RELATING TO THE SPEED AND TURNING OF SHIPS.

Curve of speed and power, representing the indicated horse-power and revolutions corresponding to any speed of the ship. The data for this curve are obtained by progressive speed trials of the ship.

Tactical diagram or turning circle, representing the path of the ship at a given speed and helm angle. From the diagram we also get the tactical and final diameters of the ship's path, her advance and transfer from the origin of the path to any other point on the path, the time occupied in passing from one point to another, the drift-angle at certain points, and the effect on the path due to *kick*.

The applicability of several of these curves to ordinary or extraordinary service will tend to show the increased power that seamen are gaining over ships.

Curve of displacement.—Dry-dock companies sometimes base their charges on displacement. The curve provides a check on the company's figures.

A ship leaves port at a known mean draft, and grounds so hard as to require a discharge of weights. If the mean draft while aground can be obtained, the corresponding displacement may be found from the curve. The difference between this displacement and that corresponding to the first mean draft is the weight to be discharged in order that the ship may float.

Curve of tons per inch.—In the case of the ship aground, the number of inches by which the ship is aground multiplied into the tons per inch corresponding to the new mean draft, or to a mean between this mean draft and the mean draft of flotation, gives, approximately, the weight necessary to be discharged as before.

By keeping account of the weight of coal and provisions consumed at sea, the curve of tons per inch affords an approximate means of finding the mean draft with which the ship will enter port; also having the mean draft for salt water, it affords a means, with the aid of the displacement curve, of finding the increased draft when passing into fresh water, and the reverse.

Curve of moment to change trim one inch.—A vessel grounds at either extremity, causing her to alter trim. If she can be made to take this trim normally, by moving weights longitudinally, she will float. The curve gives, approximately, the needed information.

A vessel having considerable drag, or a skeg, can cross a bar by altering trim; the curve gives the required relation between movable weight and longitudinal distance. Some modern men-of-war have trimming tanks in the fore and after peaks. The amount of water to be taken into a chamber may be found, approximately, from this curve and the curve of tons per inch.

Curve of stability.—If the graphical data be sufficient, the stability of a vessel in any condition of damage may be found from the curves at a glance. The risks being known, she may continue to her destination or make for the nearest port, accept or decline assistance, and continue or avoid a fight.

If it were asked where this new or extended knowledge of seamanship is to end, I should reply, at designing. Short of that, the more of this kind of information possessed by the line officer, consistent with thoroughness in other professional branches, the better for the service. Ship-designing, however, is a profession in itself, and one sufficiently exacting of energy, knowledge, and time to engage the whole attention of any man, whatever his talent. Analogy is not wanting to support my views, for it has long been thought desirable that every line officer, in addition to gunnery, should have a knowledge of ordnance, from the preparation of the metal to the completed structure, embracing the tools employed and every detail of manufacture; yet it has been recognized that ordnance designing is a specialty.

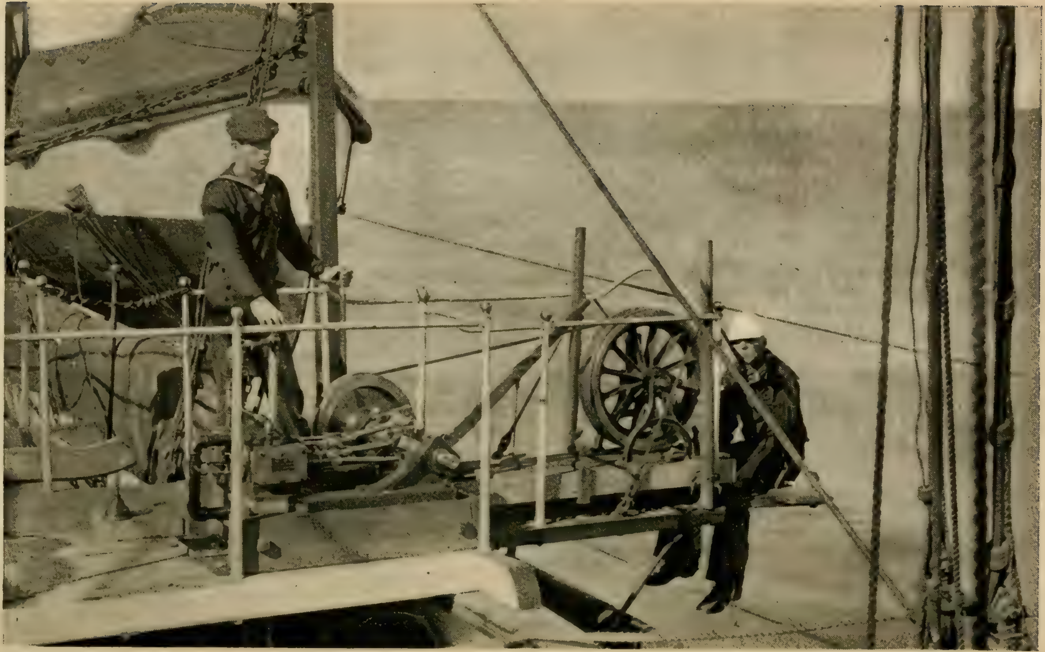
So much has been said about theory and fundamental knowledge, in this paper, that it may be well to explain that I do not undervalue practice, but, on the contrary, would associate it with theory to the greatest possible extent. In fact, information derived from practice, when equal, is always to be preferred to that gained by the study of books; but I will reiterate, that, in my opinion, ordinary service, as a school, no longer affords full opportunity for acquiring the range of knowledge needed to prepare for emergencies. Again, I do not attach equal importance to all branches of the proposed line of study, but regard that which relates to handling vessels, in general, as the most important.

My paper is already much longer than I had wished to make it, so I will not consume time by attempting to carry seamanship into tactics, or to define the exact limits of seamanship relative to kindred matters. That would hardly suggest any study, the necessity for which is not now recognized. If it is accepted that I have not left the domain of seamanship thus far, it has, perhaps, been made apparent that the reduction of sail area has no tendency to degrade the functions of the line officer. The idea of the general public is, that the line officer is only a seaman; very little is known of his character as an infantryman, light artillerist, heavy artillerist, naval and military tactician, navigator, hydrographer, expert in high explosives and the appliances of war, repository of the service knowledge of what is called the art of war, and of international law; disciplinarian, magistrate, judge, jury, and administrator afloat, and as the agent of his Government in affairs oftentimes of the greatest national concern. Leaving all this out of consideration, however, there is enough in future seamanship alone to satisfy official pride and to give the line officer ample reason to insist on rapid development in the new direction.

A noteworthy condition of the attainment of the new or extended seamanship, as laid down in this paper, is that it must come mainly from the published works of naval architects. It will not be found in works devoted to seamanship alone. In good time, after we shall have had experience with the new ships, it will doubtless come about, that we will reverse the case and give naval architects suggestive points in their own profession, but the burden of obligation is upon us at present. The benefit likely to result to us in the exercise of our duties by a ready recognition and admission of this state of things ought to be generally apparent.

Last year an officer of ability said to me, in good part, that the seamanship department of the Naval Academy had not progressed since 1868. This did not hit me hard, because I was a newcomer; but such an opinion, if actually held, would be unjust to my predecessors. The course of study has gradually improved since that date, and much of the new matter, to which attention has been called in this paper, has been taught for several years past; but the need for suitable text-books has been very discouraging. At present, Naval Constructor Richard Gatewood, U. S. N., is giving a series of lectures on ship-building and naval architecture to the cadets. These lectures are printed and issued to cadets and instructors. They are specially adapted to our needs, and it is hoped that they will result in a publication available for the service at large. In other respects the department is being brought up to date as rapidly as our facilities will allow, but time is an element of progress in this as in other matters. The chief source of concern is the outside service, not the Naval Academy.

In concluding this paper, I think Naval Academy graduates may permit themselves to feel a hearty satisfaction at the complete vindication of our system of naval education, by recent naval development. The Academy was established in 1845, and its graduates are found in the various grades of the line through the highest commanding rank for a single vessel; yet until very recently it has had vigorous opposition, more or less on the supposition that its scientific methods were opposed to practical efficiency. The gratifying result of the Academy education is, that line officers as a class, and a large proportion of the engineers of the service, are fit to meet development in whatever direction it may affect their respective duties.



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PROFESSIONAL NOTES.

THE SOUNDING MACHINE OF THE U. S. S. RANGER, AS IMPROVED BY ENSIGN HARRY PHELPS, U. S. N.

The sounding machine of the Ranger is not a new invention, but merely the original machine of Sir William Thompson modified by the addition of a few improvements, so as to produce a serviceable and reliable machine that is cheap and not liable to get out of order. A short description of this machine may be of interest.

The description will be made clearer by first giving a few of the details of the Ranger's deck and bridge where the machine is mounted. Among other alterations which the Ranger has undergone during eight years of surveying work, her battery has been removed to give greater coal capacity. In the place usually occupied by the forward pivot gun, a chart house or draughting room, about eight feet wide, twelve feet long, and seven feet high, has been erected. Across the rails at the after ends of the pivot ports is the bridge, about three feet wide, resting on the rails and chart house. Projecting from the ship's side, at either end of the bridge, are gratings about four and one-half feet square, that hook into the rail and are supported by braces from the ship's side beneath. Over the port gangway the bridge has been doubled in width; the ends of the extra portion, which is forward of the main bridge and built into it securely, resting on the chart house and rail. On the outboard end of this extension the engine of the sounding machine is placed, and the remainder of the machine is on the grating that projects beyond the port end of the bridge.

A sounding machine consists essentially of a reel for holding the wire, with a register for showing the amount paid out, an engine for reeling in, and arrangements for controlling the motions of the reel while paying out.

The reel used is the Navy steel reel, having twelve spokes, with a capacity of about ten thousand fathoms of wire, and having on one side a V groove for the controlling band. Its diameter is such that it is one fathom in circumference, less a slight correction for the diameter of the wire used. On the axle of the reel is a worm which engages one of the cogwheels of the register, to show the number of turns the wheel makes, and a ratchet wheel, in which a pawl fits, to hold the wheel in any desired position. The reel is mounted on brass standards on a bed about three feet long and fifteen inches wide. The bed moves in a trough-shaped slide, having its sides even with the top of the bed, and wide enough to allow the bed to travel freely along it. The slide is about five feet long, and rests on the ship's rail and a narrow ledge on the outboard side of the grating, being secured by screw bolts through either end. These bolts have square heads and are set in flush with the upper surface of the slide. The slide has on its outer end two iron straps that project over the bed when it is run out, and keep it from rising. The bed is run in and out by means of a brass screw about twelve inches long, that works in a nut screwed to the after end of the bed, a hole being bored in the bed to receive it. At the other end of this screw, where the threads stop, it is enlarged slightly and made hexagonal to take a wrench, and it ends in a ball having a slot turned in it for a collar. A small pillow-block fits this collar and is screwed to the bottom of the slide. A few turns of this screw will move the bed in or out as may be desired, and as will be seen it is very powerful. On the after end of the bed is a small cleat for securing the stray line, which will be referred to later on.

The engine is a double horizontal engine, having cylinders 3½ inches by 6 inches, and occupies a space about three feet square and about eighteen inches high, being blocked up in order to give room for the fly-wheel. As it needs to run but one way, the links and backing eccentrics are removed. Steam is led to the engine by a two-inch iron pipe which is connected to a joint formerly occupied by a steam-heater pipe, led forward under the spar deck, up abaft the chart house, and under the eaves of the house to the bridge where it turns outboard. Covered with canvas and painted white, this pipe is not in the way and does not detract from the appearance of the ship's deck. The drain cocks of the cylinder open into the exhaust pipe, which bends under the machine and discharges over the side through a long canvas pipe. The fly-wheel of the engine is eighteen inches in diameter, and is fitted with a clutch coupling for detaching from the engine while paying out. Its face is 2½ inches wide and has two grooves on it, a flat groove 1 inch by ½ inch deep, and a V groove ¾ inch wide and 1 inch deep. In the V groove is a band made of 1¾ inch hemp well stretched and spliced with a long splice, so that when it is around the reel and fly-wheel and taut, the reel lacks about six inches of being chock out. This band is kept taut by means of the screw in the bed-board, and besides transmitting power to the reel, serves to keep it under control at all times. The slack is to allow for stretch that is sure to occur as the band wears.

The brake is in the flat groove and consists of a strap of galvanized hoop iron about four and a half feet long, having on its under side a number of pieces of oak wood half an inch thick and three inches long and just wide enough to fit the groove. These blocks are cut to fit the curve of the wheel, are secured by two small screws to the strap, and have the grain running across the groove so as not to jam in case of splitting. They are separated by about a quarter of an inch, and there are holes in the strap abreast these openings for oiling. There is riveted to either end of the strap a rectangular link, 1 inch by 3 inches inside measure, of $\frac{3}{16}$ inch iron. Through the bottom of the slide there is a U-shaped piece of iron with one arm longer than the other. The long arm passes through the slide and has a nut underneath; the short arm resting in a socket about ½ inch deep. The link on one end of the brake strap hooks to this staple, that also carries a third link to hold the heel of the brake handle. The strap passes from this staple under the fly-wheel up and outboard over the top, and the brake handle ships through the link on the end. The handle is of ash, flat, about 1 inch thick, tapering towards the handle, being 2½ inches wide at the lower end, where it is held by the spare link described above. The upper link is kept about one foot from the lower end, and both are kept from slipping by notches cut on the edges of the handle. It will be seen that when the wire is paying out, the brake is set up automatically, and slackened when the wire is being reeled in. The weight of the handle is sufficient to keep the reel from paying out the wire faster than forty pounds of lead can sink. A small lanyard is fitted to the handle to keep it from being drawn up too far when reeling in. In using the machine the brake is kept well oiled, because it grips too hard when dry, besides wearing more rapidly and causing an unpleasant noise. The wood used on the iron gives better results than an iron strap would, and when worn out can be replaced without risking the chance of a break in the simple strap.

The steam pipe for the engine comes through the bridge near the rail, rises as high as the hand-rail, and has the throttle at the top of this portion. In the photograph the steam pipe admits steam at one end of the pipe joining the steam chests. This has been changed so as to admit steam midway between them, thus insuring an equal supply in each cylinder. The clutch is worked by a vertical lever, three feet long, that is just above the ship's side, and the clutch lever and throttle are so placed that the operator can keep a hand on each of them, and keep the register and wire astern in view at all times by a slight movement of the head. This engine was not designed for this use, but bought in open market and adapted. The price of the engine complete, with the special fly-wheel and clutch coupling, was three hundred dollars. A vertical engine would work equally well and occupy less space. Any engine for reeling in wire should be double, however, on account of the steadiness of the motion.

With a pressure of fifty pounds at the boilers, this engine easily makes three hundred revolutions per minute while reeling in a forty-pound lead, with several hundred turns of wire out and the ship steaming about seven knots. With this engine it is not necessary to reel in a single turn by hand. It can be started as gently as the reel could be by hand, and when the lead is up it can be raised as little as six inches at a time, if desired.

The sinkers used are forty-pound leads cast on board ship, with "Sand's" cups. The leads are made in an open-ended iron mould, made in halves and held together by a clamp. The lead is two feet long, two inches in diameter at the top and three at the base. The upper half is conical and the lower half hexagonal, with a uniform taper. The cups are cast in the lead by placing the plug in the end of the casting before the material sets, and they are held in place by the lead which runs in the hole left for the forelock. The sinkers are fitted with beckets to which the stray line is bent. The stray line is a piece of small rope which connects the wire with the sinker to keep the wire from coiling on the bottom, and to make the handling of the sinker easier and simpler when it is near the surface of the water. I used braided, signal halyard stuff for this purpose, using between seven and ten fathoms of it. It makes a very neat splice, and does not twist when being hauled through the water.

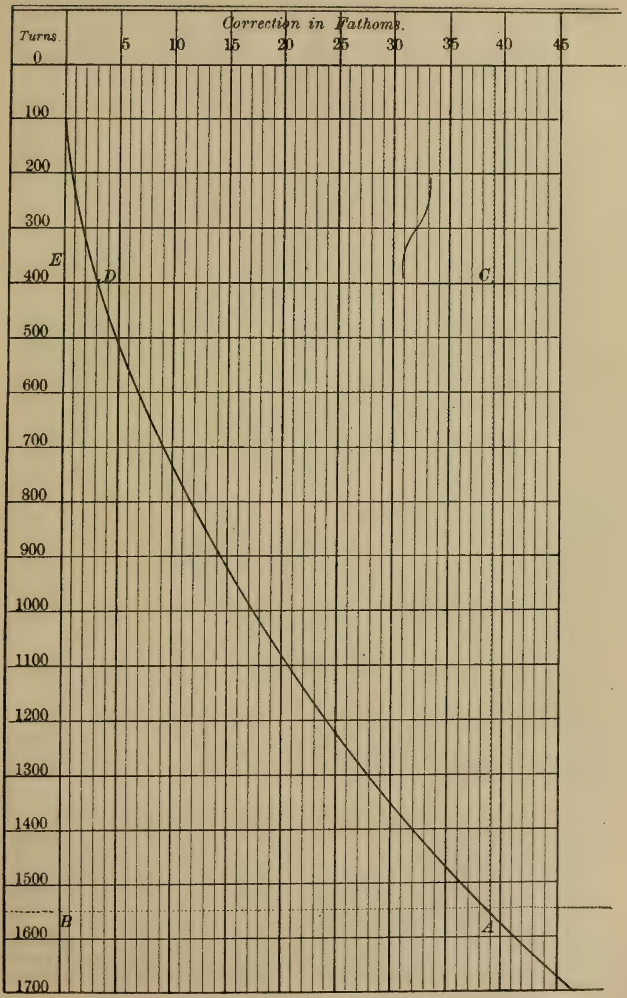
The splice is made as follows: With a file sharpen the end of the wire and then unlay about two inches of the end of the rope. Force the wire into the center of the rope about one or two inches, and then let the point come through the side of the rope. Draw through about three feet of wire, and then clamp the frayed end of the rope and the wire in a vise and haul the rope taut. Take eight or ten round turns with the wire just above where it appears through the rope, and then stick the end through the rope and haul it taut, stick again and take another set of turns, and then stick the end through two or three times and break the wire off close to the rope. Put a short seizing on to keep the end from sticking out and cutting the hand that will guide the wire. Scrape the frayed end of the rope down to a point, and serve it with twine for about two inches, securing the ends of the twine by sticking through the rope with a sail needle. This makes a neat, strong splice, and it offers the least possible resistance to being drawn through the water. With one of these splices I have taken as many as three hundred casts without an accident.

For joining the lengths of wire, I found the "Belknap" splice most serviceable and convenient. It is made as follows: Point the ends of the wires to be joined and lap them about eighteen inches. Stop one end to the other wire, and with the loose end take half a dozen turns about the other wire and stop the end to it. This will make a long-jawed twist. Now put a very small drop of solder about every two inches of the doubled portion, not enough to surround the wires, but sufficient to hold them together. Take the stops off the ends and solder the points to the other wires. This will need a trifle more solder than the intermediate points, but should not increase the size of the splice perceptibly. The whole is then served over with waxed twine. This splice being long, slender and flexible, stows very neatly on the reel without making lumps, and will adapt itself to any block it is paid out over without danger of breaking, and the very small quantity of solder necessary prevents the temper being taken out of the wire by continued heating. The splice is very quickly made, and requires no special experience to make a good one. The twine takes up any chafe that would otherwise come on the wire, and can easily be renewed should it become much worn.

The wire must be coiled on the reel in regular layers, for if ridges are formed, the outer turns are apt to spring off and the wire become bent and so rendered liable to fracture. This guiding of the wire presents no difficulty, and in a very short time any enlisted man can be taught to lay the wire on smoothly. For the man who does the guiding there is a small stage rigged beyond the end of the projecting grating; it is supported on two outriggers whose ends hook into bolts on the side of the grating, and by guys which go over the rail and hook to the grating inside. One of these guys is used to hold a bucket, that stands on the stage and holds water, in which the specimen cups are washed after the specimens have been removed. The other is useful by the man to hold on when the ship has much motion.

For reeling in when under way, a brass snatch block having a 5-inch sheave, about ½ inch wide, is hooked to an eyebolt on the forward outrigger, so that when horizontal the score is exactly under the center of the score on the reel that holds the wire. This sheave is countersunk ⅛ inch in each cheek of the shell, to prevent the wire from getting between the sheave and shell and running on the pin. This block hangs down while the wire is paying out, and is lifted up and the wire put in while the register is being read, the lead being on the bottom. When the sinker is up, the man outside takes off the specimen cup and cleans it, after removing the specimen.

The register consists of three small axes, in a brass frame, carrying cog-wheels that gear into each other, and having on their extremities index fingers which move over graduated circles. The lower wheel has 100 teeth and gears into the worm on the axle of the reel. Each of the graduated circles is divided into one hundred parts, and it will be seen that each division on the lower circle represents one turn of the reel, or one turn of wire paid out. The second pointer makes one revolution for each ten revolutions of the lower one, and the upper one makes one revolution for each ten of the second; so that each division of the middle scale represents ten turns, and of the upper scale one hundred turns, the highest record being ten thousand turns. The width of the score is such that about one hundred turns of the wire used can be put on without riding turns, and then, since the diameter of the reel has been increased by twice the thickness of the wire, it is evident that each turn is no longer an exact fathom, also that the deviation becomes greater as the amount on the reel increases. Since the register merely gives the number of turns paid out, a correction must be applied to each reading to obtain the correct sounding, and this correction is obtained from a curve in which the turns of the reel are ordinates and the corrections corresponding to each number of turns abscissae. This curve must be obtained by actual measurement of the wire when it is put on the working reel, and will always be the same for the same reel and wire, so need be obtained but once. To measure the wire, it is led from the coils in which the wire is supplied, five or six times around a spare reel and thence to the working reel. The spare reel must be exactly like the working reel, and the turns must not be allowed to ride. The registers on the two reels give the number of turns each makes, and it is evident that a simultaneous reading of the registers will give the number of *turns* on one reel and the number of *fathoms* that have passed the spare reel, and the difference will be the correction which is always additive to the reading of the register. The curve must be constructed for the longest length of wire put on the reel, and then it will serve for any smaller amount of wire. A portion of the curve is shown annexed and explains itself. The use of the curve is as follows: At the point in the column of *turns* corresponding to the number of turns on the reel, say 1550, B, draw a horizontal line to meet the curve in A, and draw a dotted vertical line through A. Evidently the length of wire on the reel is $1550 + BA$ or 1589 fathoms. Suppose in making a cast we pay out 1150 turns. Run the eye up the line AC a distance corresponding to 1150 turns, which is to C, then count the spaces from C to D, the point where a horizontal line through C cuts the curve, and we find it to be 36 divisions. Then the sounding is 1186 fathoms.


Turns.
Correction in Fathoms.
0
5
10
15
20
25
30
35
40
45
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
E
D
C
B
A

Because the whole length of wire on the reel is 1550 turns $+BA$ fathoms, and if we pay out 1150 turns there are left $400+ED$, and the sounding is $1150+BA-ED$, and $BA-ED$ is evidently CD. Should wire be lost, it is only necessary to move the point A and draw a new dotted line from which to count. If the curve is drawn on profile paper, the operation of counting spaces is much simplified by the more minute subdivision of the spaces representing turns. The register is set at zero when the sounding cup is just in the water, and when the sinker is on the bottom the reading of the register will be the actual depth in turns of wire. In this method the turns of stray line are given the same value as turns of wire, which of course is not true. No appreciable error is caused by this proceeding, as there are so few turns of stray line.

The method of taking a sounding is as follows: With the engine uncoupled, it is turned over several times to expel condensed water from the steam-pipe and cylinders, so as to be ready for reeling in. The lead being suspended as in the view, with the cup in place, the register properly set, and the band between reel and engine taut, the pawl is released, and the wheel allowed to revolve and pay out the wire. The operator, with one hand on the brake-handle, watches the wire to note any evidence of slacking and has complete control of it. The instant the lead strikes bottom the brake is pressed firmly and the reel stops within less than one turn. The man outside with a fold of canvas draws the wire slightly towards him, so that it will have a slight pressure on his hand as it pays out over it. If the wire slackens from running too fast it is felt at once in the decreasing pressure and warning given to the operator, and on striking bottom he involuntarily draws his hand back and so takes up all the slack wire that is not taken by the sinker falling over on the bottom. The pawl being put up, a slight pull on the band takes up the slack wire and the register is read. The clutch of the engine is then engaged, and the wire being in the block, the reeling in commences, the man outside guiding the wire by holding it in a fold of canvas, and the ship may steam ahead on her course, care being taking not to put the helm over so as to get the screw foul of the wire. The engine is started very gently, but as soon as a start is made, speed may be increased very rapidly. The operator, with one hand on the throttle and one on the clutch-lever (to keep it from uncoupling accidentally), watches the register, and when the lead is about twenty-five fathoms away, slows down and warns the man outside to watch for the stray-line splice, so as not to get his hand caught between the wire and reel. Great care must be exercised in lifting the lead from the water when the ship is under way, to keep it from swinging violently forward and slipping the stray-line over the flange of the wheel, which is almost certain to cause the loss of the lead. The lead being up to the reel, the cup is unscrewed and the specimen removed. The cup being washed and returned to its place, the machine is ready for the next cast. The reading of the register being corrected as explained above, the sounding and character of the bottom are written on a small blackboard attached to the rail, to be read and recorded by the recorder on the poop, where the working sheet is kept and the observations plotted. If at any time during the operation the band shows signs of slipping, a turn or two of the screw on the slide will stop it at once.

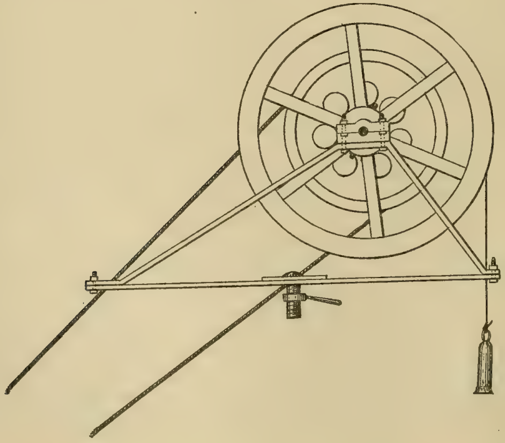
The machine is secured by slipping the band out of the scores, taking off the register (for safety), and unshipping the brake-handle. The end of the brake must be hooked to the spare link to keep it in its place, and then the stray line is unwound from the reel to keep it from rusting the wire. The splice being clear of the reel, the line is belayed to the cleat on the bed mentioned above, and the wire set taut and secured with the ratchet. Canvas covers are placed over the reel and engine when they have been cleaned, and a wooden cover is placed over the screw in the bed to keep it from being bent or injured. The machine is very easily prepared for work. All that is necessary, after removing the covers, is to ship the band, brake-handle and register, and turn on the steam, of course getting the lead over the side. From the view it will be seen that the machine does not interfere in the least with the use of the bridge for piloting, and there is nothing to catch flying gear or interfere with the working of the ship in any way.

This machine is ready for use at a moment's notice, has no delicate parts to get out of order, requires but two persons to run, has a moderate first cost, and needs practically no repairs of any consequence. It is efficient and economical and rapid in its working. It takes but half a minute from the time the lead takes the ground to read the register, couple up, and start reeling in the wire. With the same sinker, without changing a splice, I took 329 recorded casts in from 50 to 600 fathoms, in all weathers, without an accident or casualty. The bridge being near the center of gravity of the ship is not affected by pitching, and when rolling it is only necessary to slow down slightly on the lee roll when paying out. I have sounded with perfect safety when rolling 15° each way. The average speed, paying out, is 100 turns in 50″ to 55″, which is as fast as the lead would sink. The same amount is reeled in in from 35″ to 40″, though when the ship is under way, and there is no need for such speed, it is more comfortable to reel in slowly, which keeps the water from flying from the wheel in the face of the man guiding the wire.

A few remarks regarding the preservation of wire may not be out of place. The method generally recommended is, when not using the reel, to keep it in a suitably formed tank filled with sperm or linseed oil, so that the wire and reel are completely covered. This certainly preserves the wire, but, unless the reel is not to be used for several months, is not at all necessary, and causes much dirt and trouble in cleaning the wheel every time it is taken from the oil. By treating the wire as I shall describe, the reel may be kept mounted ready for use, and the wire in good condition for an indefinite length of time. Towards the end of each day's work, or after each deep cast, while reeling in the wire, let a man hold a rag well oiled against the wire in the score. Holding the hand against the inboard side of the reel, fingers down, is perfectly safe. Keep plenty of oil on the rag, so the wire may be well oiled all through. The water is stripped from the wire by the man laying it on the reel. When the reel is to be secured, the stray line is unwound and secured to the bed, being careful always to keep a slight strain on the wire. Now with a swab and hot water (fresh) wash the wire thoroughly, and dry it with the same or another swab. Pour a small quantity of oil on the wire, and rub it around the reel with rags, using enough oil to coat the wheel all around. Rub the rags over the bright parts of the reel, put a small flat pan underneath for the drippings, and put a canvas hood over the reel. If the wire is used next day it will be found bright and clean. If it is not to be used, have a quartermaster examine it every morning when bright work is cleaned. Should the wire or reel begin to rust on top, as they are apt to do from sweating under the canvas and the oil running down, a rub with an oiled rag and a few drops of oil will stop the rusting. Twice a week in dry weather is often enough to look at the wire. In this way I kept wire on the reel without dismounting it for eighteen months, during five of which the wire was not used once, the ship being at a navy yard, and at the end of that time, the wire being taken off for inspection, was found to be in as good condition as when first laid on, though there were five hundred fathoms that had never left the reel during that time.

In all surveying work, next to accuracy, time is of the greatest importance, and any device that will shorten the time for a sounding is valuable. It is customary to steam ahead as soon as bottom has been reached by the sinker, and the wire can be reeled in quite as safely while towing as when vertical. Of course at great depths the speed of reeling up should be decreased, but in no case need it be slower than sixty turns per minute, and when not more than a thousand fathoms are out, double that speed is safe with a vessel steaming eight knots, should such speed be necessary. After a cast of 650 fathoms with a forty-pound sinker, the ship started ahead full speed as soon as bottom was reached, and the sinker was brought to the reel at an average speed of one hundred turns in forty seconds, and an examination of the stray-line splice failed to show that it had been unduly strained. I have found that with this machine the wire will stand any strain the engine can put on it if the submerged end is free and the strain is gradual, not a jerk; and I may add in conclusion that the life of the wire is in keeping it taut, avoiding kinks.

Wire has been used in the launches of the Ranger with success and profit, both in time and accuracy. One turn of wire on the reels used is just four feet long, so there are 150 turns in 100 fathoms. The reel is of brass, having a flat score on its face 2½ inches broad and 1½ inch deep. There is no groove for a friction band, and the reel is keyed to an axle about 18 inches long which rests in bearings on proper standards. The register is a circular brass plate ¼ inch thick, having 150 teeth on its circumference and 100 equal divisions on its face. It is secured to a vertical plate on one of the cap squares, and is turned by a worm on the axle. A smaller plate, about 1½ inch in diameter, is also secured to this plate, and a button on the larger one engaging grooves on the smaller one causes it to register each complete revolution of the larger dial or each 100 fathoms. The correction curve already described must be used for correcting the readings of the dial, which are not turns, but approximate fathoms. Handles may be shipped on the ends of the axle for reeling in, but it is simpler to use steam for that purpose. A light brass wheel 12 inches in diameter is keyed to the axle. On its edge it has a groove ¾ inch wide and 1 inch deep, and there is a similar wheel on the shaft of the engine, bolted to the balance-wheel on that shaft. A rope band passes around these two, and is kept taut by having one part run through a tail-block which can be moved to any desired position. As this contemplates going ahead while reeling in, a snatch-block just like the one described above for the ship's reel is hooked to the rail just under the machine. In sounding, the band is used as a friction band to check the reel, and it is also stopped by grasping the rim with the hands. Nine or fourteen-pound leads are used with this machine, with about five fathoms of strong line. Soundings as high as 283 fathoms have been taken with great ease, celerity and accuracy.



As shipped in our launches, the machine rests on a platform about a foot higher than the rail (high enough to clear the spray cloths). This platform is about 15 inches square, 2 inches thick, and is secured over the thwart separating the sternsheets and engine compartment. It has five braces of $\frac{3}{16}$ inch iron $1\frac{1}{4}$ inch wide. Two lead from the outboard corners forward and aft and rest on the rail where they are secured, rising at an angle of about sixty degrees. From the inboard corners two braces lead to the rail and secure to it *inside* just abreast the other braces. A heavier brace leads from the middle of the inboard side and steps on the thwart underneath, being placed at sufficient inclination to give lateral as well as vertical support. A bolt passes through the center of this platform to secure the reel and is set up by a clamp underneath. In the bed of the machine is a slot about six inches long, to allow the machine to be run in and out.

Two frames were used for supporting the reels, one of wood and the other of iron. The latter was so far superior to the wooden one in strength and convenience that the slight additional weight, if there was any, was more than made up for. This frame was devised by Ensign W. R. Rush and was made under his supervision on board ship. The bed plate is of $\frac{3}{16}$ inch boiler iron, 15 inches by 24 inches, with a hollow cut in the front end to keep clear of the wire. The standards (of $\frac{1}{4}$ inch iron $1\frac{1}{2}$ inch wide) are bolted to the corners of this plate and are shaped as shown in the sketch; the Babbitt metal bearings for the axle being bolted to the tops by the same bolts that hold the cap squares. A long slot is cut in the bed-plate to allow the machine to be run in and out and to admit the holding-down bolt. The machine is readily unshipped from its platform, and the latter makes a very convenient step to use when entering or leaving the launch. Two men are required to run the sounding machine in the launch, one to attend the friction band and one to guide the wire.

U. S. SURVEY STEAMER RANGER,

SEBASTIAN VISCAINO BAY, LOWER CALIFORNIA, MARCH 16, 1888.

Turns of Reel as per Register.	REELING OUT.					REELING IN.				
	Times.			Intervals.		Times.			Intervals.	
	H.	M.	S.	50 f. S.	100 f. S.	H.	M.	S.	50 f. S.	100 f. S.
0	2	10	27	..	..	2	16	45	19	35
50	2	10	57	30	..	2	16	26	16	33
100	2	11	23	26	56	2	16	10	17	35
150	2	11	48	25	51	2	15	53	18	36
200	2	12	13	25	50	2	15	35	18	35
250	2	12	38	25	50	2	15	17	17	35
300	2	13	03	25	50	2	15	..	18	35
350	2	13	32	29	54	2	14	42	17	..
378	2	13	54	22	51	2	14	25	..	..
900										
1000										
1100										
1200										
1300										
1400										
1500										
1600										
1700										
1800										
1900										
2000										
2100										
2200										
2300										
2400										
2500										
2600										
2700										
2800										
2900										
3000										
Totals,										

REMARKS.

To be made by the Officer of the Deck.

Sinker used, *lead.* Weight, 40 lbs.
Was sinker detached or recovered? *Recovered.*
No. of fathoms of stray-line used, *about 10.*
No. of turns of wire in use on reel, 1600.
Kind of reel used, *Navy steel.*
Reeled in by *steam.*
Reeled in first, 0. Turns by hand.
Reeled in last, 0. Turns by hand.
Wind, *on bow.* Force, 2.
State of the sea, *long swell.*
Vessel rolling, *10° each way.*
Vessel pitching, *none.*

Ship started ahead four bells as soon as reeling in commenced. Speed, 7 knots.

LOSSES OR CASUALTIES.

None.

Reading of Register........ 378 turns.
Correction for stray-line.... ..
Correction for turns of wire. 15
Correct depth.............. 393 fathoms.

Signature of Officer Sounding, HARRY PHELPS, *Ensign, U. S. N.*

U. S. SURVEY STEAMER RANGER,

SEBASTIAN VISCAINO BAY, LOWER CALIFORNIA, MARCH 16, 1888.

Turns of Reel as per Register.	REELING OUT.					REELING IN.				
	Times.			Intervals.		Times.			Intervals.	
	H.	M.	S.	50 f. S.	100 f. S.	H.	M.	S.	50 f. S.	100 f. S.
0	3	9	..	..	..	3	18	08	34	51
50	3	9	26	26	..	3	17	34	17	33
100	3	9	49	23	49	3	17	17	16	33
150	3	10	11	22	45	3	17	01	17	37
200	3	10	36	25	47	3	16	44	20	38
250	3	11	02	26	51	3	16	24	18	34
300	3	11	26	24	50	3	16	06	16	37
350	3	11	53	27	51	3	15	50	21	39
400	3	12	21	28	55	3	15	29	18	41
450	3	12	49	28	56	3	15	11	23	..
490	3	13	11	22	50	3	14	48	..	..
1100										
1200										
1300										
1400										
1500										
1600										
1700										
1800										
1900										
2000										
2100										
2200										
30										
2400										
2500										
2600										
2700										
2800										
2900										
3000										
Totals,										

REMARKS.

To be made by the Officer of the Deck.

Sinker used, *lead.* Weight, 40 lbs.

Was sinker detached or recovered? *Recovered.*

No. of fathoms of stray-line used, *about 10.*

No. of turns of wire in use on reel, 1600.

Kind of reel used, *Navy steel.*

Reeled in by *steam.*

Reeled in first, 0. Turns by hand.

Reeled in last, 0. Turns by hand.

Wind, *on bow.* Force, 2.

State of the sea, *long swell.*

Vessel rolling, *10° each way.*

Vessel pitching, *none.*

Ship started ahead four bells as soon as reeling in commenced. Speed, 7 knots.

LOSSES OR CASUALTIES.

None.

Reading of Register........ 490 turns.

Correction for stray-line.... ..

Correction for turns of wire. 22

Correct depth............. 512 fathoms.

Signature of Officer Sounding, HARRY PHELPS, *Ensign, U. S. N.*

THE PROTECTION OF CRUISERS.

By E. Weyel.

Translated from *Le Yacht.*

The old armored English frigate that has so frequently been blown up with torpedoes, now serves as a target for shells charged with high explosives. Up to the present time they have made, on the other side of the Channel, a great mystery of the results obtained in this practice. They not only will not permit visitors to examine the effects of the explosions, but still further to prevent any indiscretion they have covered the sides of the ship so as to hide the numberless wounds. Not a single account of the trials has been published, but our friends over the water have too much sense to ignore the views of the officers of all branches of the service who have assisted in the experiments. They have finally announced that the Resistance is to be patched up so they can experiment on the most efficacious method of protection against these engines of war, and they seem to hope in the English Admiralty that by covering her sides with thick beds of coal, separated by very thin sheets of metal, they will obtain a sufficient protection. Our experts believe, on the contrary, that this system can never be anything but an expedient, and it is as well to say that this is not a recent invention.

Towards the end of the Turco-Russian war the situation between England and Russia was strained. The Russians knew very well that they were not in a condition to cope with England on the sea, but they did not forget that their rival was vulnerable through her merchant marine. From this sprung the idea of building a fleet of Alabamas that would have scoured the seas if the rupture between the two countries had taken place. The Admiralty intended to oppose to these cruisers armed auxiliary steamers, but it was necessary to find some method of protecting their machinery. They experimented upon an old condemned ship, the Oberon, and adopted an ingenious system of protection. They made a wall of coal, interspersed with thin sheets of iron, riveted only on their upper edge. The shells fired against this target entered into the mass, but failed to reach the interior compartments. This was for the time a sufficient protection, but it is doubtful if that which succeeded against shell charged with ordinary powder would have been as efficacious had the shell been charged with melinite.

It will be remembered that in 1887, under the administration of Admiral Aube, we made experiments with these latter projectiles by firing at the old armored vessel the Belliqueuse. The results have been kept secret, but as a little while afterward they placed on the stocks the armored cruiser, the Dupuy-de-Lôme, it would indicate that the information given of the serious effects of these explosives was not exaggerated.

It has been unanimously decided by the Board of Control to protect with armor even the less vital portions of the ship, that is to say, to return to armoring all the exposed portions of the vessel; but the reasons for this decision have remained almost unknown. For my part, at the moment when they decided upon such a return I believed it to be a little too radical; to pass at a leap from sides of ordinary ship-plate to the armoring of the entire visible surface of the ship seemed to me an exaggeration. A very distinguished general officer, to whom I expressed my astonishment, had very little trouble to convert me. "There is," said he, "beyond the effects of the shell that you know, the effects of the destruction of the decks that are terrible." I took good care then not to publish what was said on this particular point, for it was not advisable to instruct foreigners. But if I am asked, why then speak of it now? my answer is very simple: the disclosing of the results of the experiments has been entirely too general to be kept as a secret any longer. In fact, the *Nouvelle Revue* published on the 15th of October an article entitled "A New Peril of the Sea, par Commandant Z..." I do not discuss the ideas of this officer, because arguments are often sterile, and also because the author of this article does not make himself known. He is evidently a partisan of the doctrines of Admiral Aube, since he recommends anew the famous gunboat. Such a vessel would throw projectiles charged with melinite and surely destroy an armored cruiser—such is his theme. In effect he says, after having described the experiments against the Belliqueuse: "We can then firmly decide that a battleship against which a gunboat, almost invisible from its small size and quick movements, should have fired a half a dozen steel shell charged with melinite, would be out of the fight." The misfortune is that with the least swell the shell will not hit one time in a thousand. For example see the attempts of the old gunboat Gabriel-Charmes. But let us return to the results of the experiments against the Belliqueuse: "They fired against the Belliqueuse with guns of 14 and 16 centimeters designed in 1881, loaded with shell ordinarily weighing 30 kilogrammes and at the outside 45 kilogrammes, the first containing only 2.800 k. and the second 4 k. of melinite. Here is the result: the explosion takes place usually after penetrating, but sometimes in the sides themselves. The fragments of from 10 to 40 grammes, numbering nearly 1500, each one animated with prodigious velocity, are thrown in all directions, even backwards, destroying everything not thoroughly protected. The remainder of the projectile is reduced to a metallic powder that penetrates all the surrounding obstacles. To these results must be added those of the explosion itself, that is local but which has great power. If it takes place while the shell is penetrating the sides of the ship, it clears a path of 1.50 m. diameter. When the explosion takes place between decks they are broken up by shattering the beams, and the partitions and bulkheads are forced in. It can also start a fire, as that happened three times in a dozen shots on board the Belliqueuse. Finally, the movements caused in the atmospheric mass are so powerful that all delicate mechanisms of the vessel, even at a considerable distance from the explosion, are rendered useless."

This is a brief of the information, and it is clear. Our neighbors over the water and others well know how to profit by it. Above all, I think we owe our thanks to the *Nouvelle Revue* for the interesting communication; it will enable us to decide with entire security the needs of a new war fleet, and it will give, I hope, a salutary fillip to public opinion. They have certainly foreseen on the other side of the Channel that they will be obliged to return to completely armoring the entire superstructure. The Admiralty cannot ignore the Dupuy-de-Lôme being placed on the stocks; still they have only the most vague information of these explosives. The proof of this is that General Maitland, in command at Woolwich, said publicly, a few days ago, that we had made a great advance on this point beyond the English, and that Professor Abel must endeavor to find a composition equal to our melinite. I trust that the secret of this explosive has not been carried to England, notwithstanding the search he made himself during one of his trips to France.

But the English are a long-headed people; they do not need much reflection to see that certain of their armored vessels, against which their public men are continually thundering, can still render them very good service. These are the Warrior, Black Prince, Achilles, Agincourt, Bellerophon, Minotaur, and Northumberland, that, being built of iron with thin armor and deficient armament, have been classed for a long time among the obsolete types. We advise our neighbors not to demolish them, for by changing the machinery of these old vessels, and by modifying their internal arrangements, they can be utilized as armored cruisers. They never can be swift vessels, but they will be good vessels to cruise for the protection of the great commercial routes.

Unfortunately we have not the same resources in our fleet; our first ironclads—those of the period of the Warrior—being of wood, are not of the slightest value. The Heroine alone could be improved; as to the Couronne, the second and last of our armored vessels built of iron, she would be of service to-day after a total change of armament. Very well, as we have no resources in our old material such as the English find in theirs, the course for us to pursue is plain. We must start new cruisers on the stocks as soon as possible; cruisers so designed that the danger from shells of melinite, hellite, bellite, etc., etc., will be limited as much as practicable, and the shells explode on the outside; that is to say, between the vitals of the ship, the gunners and the guns, there should be a shield almost invunerable. Protection by use of coal can only be an expedient, even admitting that it will not prove dangerous under the action of high explosives; and with the hypothesis that has not been proved, that it would efficaciously protect the hull of the ship, still this protection is not sufficient, because it ceases from the moment it becomes necessary to drive the ship and thus to burn her protecting armor.

It is necessary for us, then, to have armored cruisers. We cannot be contented with the cruisers of the third class, as they are ships without guns, having none of the qualities of a cruiser, and good solely as scouts for the fleet; and if I speak of these vessels, it is because we will have nearly all of them in 1889, and because they form the majority of our fast cruisers. It may be well to recall the reservations made when these ships were on the stocks. For my part I have always protested against the construction of these six cruisers of the third class, of the type of the Forbin of 1850 tons; they are badly armed and of very poor design. As to the cruisers of the second and first class, we must wait for them, except the Davoust, one or two years longer at least. One can then hope to see the desired armored cruisers built at the same time, but for this it is necessary to take active steps and to silence all considerations of a secondary nature. We must ask for 25 to 30 millions francs from Parliament; and as the dockyards of the State are overcrowded with work, we must have the new cruisers built by private firms. The delays will be discussed with care, and in order to insure dispatch a bonus will be given for each month they gain in delivering her before the specified time, and, on the contrary, a double penalty will be exacted for each month they are behind. This system will have the merit of stimulating the zeal of the contractors. This would be the principle usually followed in engines. When they develop a greater power than was expected the contractors receive a premium. Very well, if a shipbuilder has by his energy and enthusiasm built a ship sooner than was expected, the service should be recognized by a sum of money. Private interest is a great motive-power. The English never forget this.

R. W.

ON THE POSSIBLE EFFECT OF HIGH EXPLOSIVES ON FUTURE DESIGNS FOR WAR-SHIPS.

By Captain C. C. P. FitzGerald, R. N.

[Repr. from the *Trans. of the Institution of Naval Architects*, July, 1888.]

The data which I have been able to collect with reference to my subject are so extremely meager that I feel almost ashamed to bring it before this Institution in its present stage, and my only excuse for doing so is the great interest and importance which attaches to it, and the urgency, if I may so express it, of the subject of high explosives used in shell fired from regular powder guns, not pneumatic tubes. I am also in hopes that some of our naval architects may have been prying into the future by watching experiments and collecting information, and that they, perhaps, may be able to throw more light upon the subject than I can do, and that the discussion which I hope will take place will at any rate cause us to realize that we are face to face with a new method of attack, which may very possibly call for some modification in ship designs for war purposes.

In spite of the cloud of secrecy which our neighbors have endeavored to cast about the subject, we have been aware for some time back that they have been making experiments with a high explosive called melenite, a species of blasting gelatine that, I am informed, is poured liquid into the shell and allowed to solidify.

The explosive force of melenite is about equal to gun-cotton, weight for weight, but volume for volume it is much greater; that is to say, melenite is heavier, so that in a given space, say the interior of a shell, you can put half as much again of melenite as gun-cotton.

The difficulty of using high explosives in shell hitherto has been the liability of concussion of the gun causing the shell to burst in the bore and thus to destroy the gun.

How this difficulty has been overcome I am not in a position to tell you; but that it has been overcome in the case of melenite we are very well assured, as numerous experiments have been carried out with it.

As to the much more sudden and destructive effect of what are called the high explosives, as compared with gunpowder, you are, no doubt, all aware. An ordinary gunpowder shell fitted with a percussion fuze, when it struck the thin side of a ship which it was capable of penetrating, passed several feet onwards before it exploded; but shells fitted with high explosives are said to burst actually on contact, or when the shell is passing through the thin side, so that the destruction caused is out of all proportion to the gunpowder shell, many square yards of the side being actually blown away, or, as it was graphically described to me, nothing left but daylight. On the other hand, it is somewhat cheering to hear that there is an antidote, and that very moderate armor is capable of breaking up these high-explosive shell and rendering them comparatively harmless. Thus it is stated that steel armor four inches thick is capable of breaking up the melenite shell from the French 16-centimeter gun—a gun about equal in power to our 6-inch gun. If this is really the case there is something hopeful in the prospect for this country, as it points to an important future for our numerous so-called obsolete thin-armored ships. They are iron-built, and although they lack many of the best features of modern ships, such as numerous compartments, double screws, under-water steering gear, etc., they would seem to be worth re-engining and re-arming, not with two or three heavy guns, but with numerous light, quick-firing ones, firing high explosives. They would, I believe, prove formidable fighting machines against any partially armored ships.

It is stated that the new French cruiser, Dupuy-de-Lôme, of 4000 tons and a speed of nineteen knots, is to be plated with 4-inch steel armor, for the purpose of breaking up high-explosive shell, though she appears in Lloyd's "War-Ships of the World" as only a "deck-protected" cruiser. It is also stated that the French are plating their coffer-dams with a similar object. This would be internal armor with a vengeance. But I only give you the report on hearsay evidence. Very possibly some of you may have better information, and if so, I hope you will give it to us.

One thing is quite certain, and that is, that our neighbors across the Channel are worth watching. Somehow or other they generally manage to take the lead of us in other matters besides the cut of a dress or the trimming of a bonnet. I say it without an idea of reproach to our own countrymen. The French are a quicker-witted and a more imaginative race, blessed with a subtler genius, whilst we, perhaps, may pride ourselves on greater solidity and firmness. At any rate, we cannot change our national characteristics, and I am not sure that it is altogether a disadvantage to allow others to go ahead and try experiments for us, provided we watch closely and do not allow ourselves to get too far astern; but this latter is an important proviso.

The French had the first steam three-decker, the first ironclad, and they were years ahead of us in heavy breech-loading guns. During the last war we were not too proud to copy the models of their sailing ships, which were universally acknowledged to be superior to our own; and I am not quite sure that if we had adopted the same course in the present day we should not have a more powerful and trustworthy Navy than we have at present, though this, of course, is a matter of opinion, as the ships have not yet been tried in battle.

I am not in favor of slavishly copying the French or any other nation, but I say that they are worth watching.

It seems to me that we are working round in a circle in this question of guns and armor; and the introduction of quick-firing guns of 6-inch caliber, and the very probable introduction of high explosives in shells, will, I think, necessitate a return to moderate armor and lighter armaments altogether; with, possibly, the abandonment of very heavy guns afloat, as not being worth their weight and trouble, when the slowness of their fire is taken into consideration.

The almost complete sacrifice of a ship of 10,000 tons to the carrying of two or three heavy guns seems to be a miscalculation of the chances of hitting from a moving platform; for gunners, after all, even behind armor, are only human beings and liable to make mistakes; and it seems likely that the introduction of high explosives in shell of moderate caliber will help to bring us back again to some modification of the type of our earlier ironclads, so as to insure us against the greater number of chances; for we must ever bear in mind that it is simply a question of chances. There is no absolute safety, nor anything approaching to it, in any design of war-ship; and the recent practice of reducing greatly the extent of armor, for the purpose of thickening it in places, has exposed large areas as happy hunting-grounds for high-explosive shell of small caliber. Almost all modern ships have many such places that they cannot afford to see destroyed with impunity.

I should like to know, for instance, how those huge Italian ships, with hardly any armor (ships which some of our naval architects so greatly admire), will get on when their sides in the region of their water-lines are attacked with high-explosive shell and large areas of them blown away. I should imagine that they would get a heavy list, if indeed the righting lever does not disappear altogether, and I cannot see that the weight of armor expended in their submerged deck will be of much value to them.

It will be seen that my remarks are merely intended to be suggestive. I have made no attempt to dogmatize on the subject of high explosives. The question is in an untried and speculative stage, and my only object is to draw attention to it, and to urge our naval architects to watch closely the experiments which are about to take place with the Resistance in this connection; and I sincerely hope that there will be no hollow pretence at secrecy about these experiments, for the only result of such tactics will be to hide useful information for a certain time from our naval architects, whilst foreigners will certainly obtain all they require.

REPAIRS OF THE FRENCH TRANSPORT SHAMROCK.

[Translated from the *Mittheilungen aus dem Gebiete des Seewesens.*]

By Lieutenant E. H. C. Lentze, U. S. N.

The French transport Shamrock, of 5700 tons, on a homeward-bound voyage, ran on a reef off the coast of Ceylon. After she was gotten off it was found that she was leaking in the forward cargo-space, which was separated from the fire-room by a water-tight bulkhead. It was found also that the leak extended underneath the fire-room; but, because of the double bottom under this part of the vessel, it seemed to be of less consequence than it afterwards proved to be. The water gained so rapidly, that in order to have all the apparatus for expelling water working, the main engines had to be kept moving.

After this was done, all immediate danger was over, and the vessel started for Colombo, the nearest port where repairs could be made, although the vessel could not be docked. The nearest dock was at Bombay, and it was not thought wise to try to make that place.

As soon as the ship arrived off the breakwater at Colombo her condition was signaled, and in a short time powerful centrifugal pumps, belonging to the British-India Company, were sent on board. As soon as they were at work they were able to stop the ship's engines without danger. The ship was then taken inside of the breakwater and moored there.

It was very fortunate that the ship had several divers, skilled in different trades, among her crew, as there were none to be had at Colombo.* These divers commenced their investigations forward, and it was found that in spite the ship's striking while at normal speed, 14 knots, neither the stem nor the plates adjoining it seemed to be injured. This was also substantiated by the fact that no water entered the vessel forward of the collision bulkhead. The reports of the different divers were carefully compared, and they agreed that there were two rents in the bottom plating lying directly one abaft the other. They were of varying width, and had a total length of about 5 meters. They were on the port side in the third streak, counting from the keel, of the bottom plating. The forward rent, underneath the cargo-space, was the shorter, extending in a fore and aft direction for 0.5 meter, of irregular shape, and about 25 cm. in width. The uninjured space between the two rents was exactly under the water-tight bulkhead between the cargo-space and the fire-room. The other rent was within the limits of the double bottom, under the boiler and side coal-bunker, and was about four meters long, of varying breadth, and had several thwartship cracks, running mostly toward the keel.

Although this information was exact, it did not give sufficient data to commence work upon. In order to obtain these, the best two divers were sent under the bottom with large sheets of lead that they hammered into the rents, and thus obtained their exact dimensions, shape, etc. Saddles, to be put on the outside to cover the rents, were procured. The saddle was made of three pieces. The one to go underneath the forward rent was a piece 90 cm. square. Those to go underneath the after rent were made so as to be put close together and form a trapezium three meters in length and 1.2 meters on one side and 0.9 meter on the other. They were made of strong plank closely joined and strapped together with iron bands, and covered on the inside with felt of such thickness as to take well in between the broken and bent parts. On top of this felt and along the edge was stretched a sheet of india-rubber so as to make a water-tight joint. Up to this time no difficulty had been experienced, but then came the task of fastening the saddle to the bottom. For this purpose the existing rents were utilized, and such places in them were chosen where the width was sufficient to admit iron bolts of diameter large enough to have sufficient strength. Holes were drilled in the saddle to correspond with these places. The bolts were T-shaped, the arms being long enough to reach well over on the uninjured parts of the plates or to the frames. After these bolts were passed through the cover, nuts were put on them and were set up as tight as possible, and then all seams and openings were caulked with cotton. While the saddles were being made the divers were at work caulking the branch rents, which were mostly towards the keel. The saddle would have had to be made too large to cover all these branches. The shape of the plate was not injured in the vicinity of the cracks, and they were stopped up by wooden wedges, pieces of lead, and oakum dipped in tallow, or by tallow alone.

These measures were entirely successful, as they reduced the amount of water entering in the cargo-space to a mere sweating, and under the boilers to a small stream.

While this work was going on the pumps had to do quite heavy work, and the seven days necessary to effect these repairs did not pass without serious alarms, caused by the temporary stoppage of the pumps and pulso-meter, which had also been installed. The repairs were finished in eight days, and when the compartments were pumped dry, the exactness of the information furnished by the divers was established. It was also seen that in the forward cargo-space the injuries were confined to the rent in the bottom plates, but the damage in the fire-room was of a more serious nature, as six of the frames were found in a very serious condition. The outer frame-angles were broken and the floors bent and torn. This damage had to be repaired before the ship could proceed on her journey.

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* This seems to point to the necessity of having such men on board every vessel.

Before commencing this it was found advisable to repair the rents from the inside. It was decided to do this by pouring cement into the cellular spaces between the frames, and this cement was to reach from the uninjured frame forward of the rent to the first uninjured frame abaft it. This mass was divided into two parts by the water-tight bulkhead already mentioned. The cement could not be put into the spaces without preparation, as there was still enough leakage from the outside to keep the plates wet and to prevent the cement adhering and hardening. In order to confine this wetting to as small a space as possible, a gutter of wood was built over the leak after it had been covered with sheet lead. One piece of wood was put perpendicular to the bottom on the keel side of the rent and fitted and wedged between the frames, and another piece was inclined against this, making a triangular gutter. All seams were caulked and made water-tight. This was covered with sheet lead and its seams and edges filled with clay. A drain-pipe was then introduced into the upright piece of wood and carried across to the starboard side of the vessel. The cells were then filled up with cement that hardened and adhered to the iron. After it had become sufficiently hard, the pipe leading from the gutter was plugged so that all the water which entered was confined to it and the gutter. After that the cement was covered by plates fastened to the reverse frame-angles. All this work was done so well and solidly that the outer saddle could have been dispensed with. It had served its purpose by reducing the leak enough to allow the inside work to be done.

The only thing that now remained to be done was the strengthening of the broken frames. In order to make this operation clear, it is necessary to state how the vessel was constructed. The frames at these places consisted of outer frame-angles intercostal between the longitudinals, to which the bottom plating was fastened while the reverse frame-angles were continuous. The space between the frame-angles was filled by floors of sheet-metal, with pieces cut out to lighten them. The upper part of this structure, namely, the reverse frames and the portion of the floors above the holes, were left intact, while the lower or outer parts were injured. In repairing, of course, the intact parts were utilized. The sheets which were to be fastened to the frames to cover the cement were greatly strengthened and lengthened so as to take in several uninjured frames. These sheets then served the same purpose as the gutter plate does on a flat keel. These alone gave the vessel almost its original strength, but to make sure, frame-angles of the same dimensions as the outer ones were bolted through the covering sheet to the reverse frames, and these upright sheets were fastened to the vertical parts of the frame-angles. This completed the repairs and brought the uninjured parts to the support of those broken.

The vessel resumed her voyage sixteen days after her arrival in port, and almost immediately ran into a short rough sea that caused her to labor heavily and tried the repairs in a more severe manner than a long ocean swell would have done. Everything proved satisfactory. The vessel averaged eleven knots on her voyage from Colombo to Toulon, and made about three tons of water per hour, so that one hour's work with one of the small pumps in each watch kept her free.

THE PITTSBURGH CAST-STEEL GUN.

This gun was contracted for under the authority of the Act of Congress approved March 3, 1887. The contract price was $3300. The chief requirements of the specification were as follows : The castings from which the guns are to be made must be composed of steel of domestic manufacture, made from the best quality of raw material, uniform in quality throughout the mass, and free from slag, seams, cracks, cavities, flaws, blow-holes, unsoundness, foreign substances, and all other defects affecting their resistance and value.

It was cast in one piece, except the breech-plug, by the Bessemer process, at the works of the Pittsburg Steel-Casting Company. It was rough-bored and turned, and then treated by the application of heat in a pit. The firm called this latter process annealing.

The following table shows the results of the physical tests made at the Washington Yard :

Specimen.	Tensile strength per sq. in. Pounds.	Elastic limit per sq. in. Pounds.	Elongation after fracture. Per cent.	Reduction of area after fracture. Per cent.
Muzzle :				
Longitudinal, ...	81,185	40,461	18.00	21.26
Transverse, ...	80,722	43,035	18.25	20.79
"	79,174	40,979	15.55	18.75
Breech :				
Longitudinal, ...	88,973	51,693	9.15	10.89
"	89,686	51,693	10.35	13.88
Transverse, ...	75,527	51,693	2.65	2.79
"	73,847	59,332	0.60	1.60
"	73,236	55,258	1.85	4.35

Payment was to have been made after the statutory test had been passed successfully. This test requires ten rounds to be fired as rapidly as the gun can be loaded by hand and discharged ; the weight of the projectile to be 100 pounds, and the powder to be sufficient to produce a muzzle velocity of 2000 feet per second.

The gun was cast in January, 1888, was 16 feet long, and weighed when finished 10,510 pounds. The test took place at the naval proving grounds on Dec. 5, 1888. A reduced charge was first fired to test the fittings. Then the gun was charged with a 100-pound projectile and 48¼ pounds of brown prismatic powder and fired. It burst at the first round, that portion to the rear of the trunnions into small fragments. The pressure-gauges were found uninjured, and showed the pressure to have been a little over 14 tons. With the charge used, the usual pressure in the bore is about 15 tons. R. W.

THE 34-CENTIMETER GUN.

The opponents of the built-up steel guns may draw a little consolation from the bursting of the 34-cm. gun on the Amiral-Duperré. But when all the facts come to light, it may be found that the construction of the gun was not faulty, and that the source of the disaster must be looked for elsewhere. The gun was of the model of 1875, and designed to fire charges of 246 pounds of W. 30/38 powder; it burst when charged with 304 pounds of P. B. S. powder (chocolate powder). It is rumored that the French, in experimenting for increased velocities, have been adding small quantities of high explosives to the charge, and have obtained muzzle velocities of over 2300 feet seconds. It would be interesting to know the amount of augmented pressure in the bore.

R. W.

BOOK NOTICES.

THE GRUSON QUICK-FIRE GUNS, CARRIAGES, AMMUNITION AND BALLISTICS.

In the first part, a complete description, with drawings, is given of the breech mechanism, together with instructions for mounting, dismounting and using it. The second part includes a description, with drawings, of the guns, their mountings and ammunition. There are three calibers given—the 3.7 centimeters, length 23 calibers; the 5.3 centimeters, of lengths of 24, 30 and 39 calibers; and the 5.7 centimeters, of 25 calibers length. The third part includes the range tables for these various guns.

The gun material is crucible steel of a tensile strength (minimum) of 35.5 tons, and an elastic strength of 16.5 tons. The breech-block works similarly to that of the Hotchkiss guns, there being, however, but one handle on the right side, which throws upward and forward to close the breech. The extractor acts differently, and the action of the hammer is much more complicated. There is a great variety of ammunition, the shrapnel being fitted with a readily adjustable time-fuze which forms the head. The Desmarest fuze is used in the shell. One shell, called the ring shell, is formed internally of a number of star-shaped rings of eight points, the body of the shell being cast round these rings. Experiment has shown that these shell for the 5.3 cm. gun break on explosion into sixty effective pieces.

The charge for each gun is about one-fifth the weight of the projectile, this latter differing little from the Hotchkiss. The powder used is rather small-grained, and the initial velocity is low. Trials have been conducted with improved powders and better results obtained, but no range tables have been determined as yet. Trials for endurance have given excellent results, two thousand rounds having been fired in some cases from the same gun without a trace of erosion or other alteration internally. J. H. G.

RESEARCHES ON EXPLOSIVES. FIRED GUNPOWDER. By Captain Noble (late R. A.), F. R. S., etc., and F. A. Abel, C. B., F. R. S., etc. A reprint from the Proceedings of the Royal Society, by the Artillery School Press.

These researches contain a detailed description of the numerous valuable experiments of Messrs. Noble and Abel, which, it may safely be said, form the basis of all modern theories on the action of powder in guns and enclosed spaces generally. Comment at this day on these experiments, the worth of which is so well known, is unnecessary. They show, among other things, the pressures (measured with crusher gauges) obtained when powder is exploded in various volumes. They prove that a part of the products of combustion of powder is, immediately after firing, in the liquid state, and that the volume of this liquid is about the same as the original aggregate volume of the powder grains.

From their experiments, Messrs. Noble and Abel argue that the liquid residue imparts heat to the gaseous products as the gases expand in a gun, and this is the main point in which they disagree with other authorities on the same subject, as Messrs. Bunsen and Scheschkoff, M. Sarrau and M. Sebert, who argue that the gases must have more time than that occupied in a gun to part with or absorb an appreciable quantity of heat. These, in turn, argue that the liquid residue heats the gun by radiation and contact.

Messrs. Noble and Abel's formula for the work that can be done by a charge of powder in a gun is deduced on the supposition that the powder is all burnt at the instant of maximum pressure. A certain factor of effect deduced by experiment is then applied, to get the actual work done in the gun. This is of doubtful efficacy with slow powders, inasmuch as it is variable for different guns with quick powders. The work done in a gun by a quick powder approaches very closely to that done by the maximum powder (on the principle that a function near a maximum varies very slowly), and may, for practical purposes, be considered the same. The true theory of expansion would then give a factor of effect constant for different guns, if quick powders of the same force were used in all the guns.

Messrs. Noble and Abel do not touch on the subject of maximum powders, though the fact that such powders exist seems well established. Altogether, however, they have supplied a fund of exceedingly valuable information to students on the action of powder in guns. The subject, in view of the large charges now used in naval guns, is of especial interest to naval officers.

J. H. G.

DEFENSE OF THE SEA-COAST OF THE UNITED STATES. By Bvt. Brig.-Gen. Henry L. Abbot, U. S. Army, Colonel Corps of Engineers.

General Abbot has given in this book his course of five lectures delivered before the U. S. Naval War College. These lectures contain a very clear exposition of modern thought and modern experience upon the subject of sea-coast defenses, and should be read by all naval officers. The weak points in the lectures will be found just where an army officer's plans might reasonably be expected to be weak, that is, where the part to be undertaken by a naval force is touched upon.

In the fourth lecture, under the head of attacks by daylight and by night or in fogs, the lecturer undervalues the damage that may be done to the system of mines by creeping, sweeping and countermining, and the necessity of a naval force to prevent the destruction of his mines. In his opposition to the dynamite torpedo gun, he fails to see its usefulness to the attack when operated as a counterminer. Under the head of naval co-operation he exaggerates the importance of land defenses. He says: "So far as the position permits, the means of defense should be confined to the land; in that way only can economy, permanency, and security against torpedo attacks be secured." As a partial illustration of this, he compares the cost of a fortress to that of a floating battery, but ignores the fact that the floating battery can move from point to point. Nothing is more clearly shown by modern experience than that without a naval force to aid the land defenses, a sufficiently powerful fleet will eventually destroy any system of mines and force a passage. Also that the land defenses should be sufficiently strong to resist the attack of two or three vessels and delay the advance of an enemy's fleet, leaving to the naval force the duty of preventing the success of large fleets. In other words, it is necessary to protect our ports against sudden dashes of a fleet or attacks made by a few vessels; but if all of our ports, or even our more important ports, are to be protected by land defenses against the attack of modern fleets, the cost would be far in excess of that necessary to create and maintain a naval force that would make us master of the seas.

R. W.

BIBLIOGRAPHIC NOTES.

ANNALEN D. HYDROGRAPHIE U. MARITIMEN METEOROLOGIE.

16TH ANNUAL SERIES, NO. 9. Results of the meteorological observation for five years at Imperial Observatory in Wilhelmshaven (Dr. P. Andries). The inside passage between Tanga and Wasin, east coast of Africa (reports of Commander von Hoven, commanding H. I. M. S. Nautilus). Report of Captain K. Jost on voyage from Cardiff to Hong Kong, from September 7, 1885, to January 30, 1886. Banks Islands. Quarterly weather review of the German Observatory. Minor notices: On the penetration of light through water; The lagoon of Vichuquen, coast of Chili; Currents between Yokohama and Hong Kong; Tamatave, Madagascar.

NO. 10. Changes of rates of chronometers at sea (Dr. F. Balte). Hydrographic notices about several places in the Samoa Islands and survey of the harbor of Safatu, by Commander Aschmann, commanding H. M. S. corvette Carola. Report of Commander von Eikstedt, commanding H. M. S. Iltis, about the navigation of Hirado Straits. Report on a voyage from Lombak Strait to Macassar, thence to Banda, Menado, and back to Macassar, by Captain C. Hunnes, commanding three-masted schooner Albatross. Soundings in the Pacific ocean on the coast of North and Central America. Meteorological observations in the harbor of Cameroon, by H. M. S. Habicht. Quarterly weather review of the German Observatory, winter 1884–85. Remarks on wind, weather and currents in the northwestern part of the Indian ocean. Custom-house regulations for the lower Weser. Minor notices: On the use of oil at sea, on board H. M. S. Ariadne; Observations of H. M. S. Leipzig on a voyage from Aden to Zanzibar; Soundings to northward of Saya de Malha bank and between it and the Seychelles; Soundings of Gettysburg bank; Winds between Kobe and Yokohama; Battle post.

NO. 11. Current observation at the mouth of the Weser. Extract from the report on a voyage from Cooktown to Matupi via Apia (H. M. S. Eser). Approaches to Cape Guardafui. Extracts from the report on a voyage from Singapore to Manila and Hong Kong (H. M. S. Iltis). Rat Island, Houtman Abrolhos, West Australia. Remarks on Raiatea, Society Islands, by Captain G. Höckelmann, commanding German bark Saturnus. Report of Captain J. H. Stege, of the German bark Pallas, on Townsville, Queensland.

Voyage from Townsville to New Castle. Remarks on New Castle and Mazatlan. Voyage to Corinto and from Corinto to Tamarindo and return. Description of weather in Corinto and Tamarindo. Soundings in the South Atlantic ocean on the east coast of Patagonia. On the variation of the magnetic declination in Rio Janeiro. Quarterly weather review. Minor notices: On the use of oil for quieting the ocean; Amount of curvature in storm-spirals; Pilots in Messina Straits; Deepening of the Guadalquivir; Soundings north of Saya de Malha bank and between it and the Seychelles; Sailing directions for the harbor of Ilo Ilo, Philippines; Position of Conway reef, Fiji Islands; Channel to the roads of Mua, Wallis Islands; Sailing directions for Fangaloa Bay, Samoa Islands; Positions of the islands Keppel and Boscawen between the Fiji and Samoan islands; Non-existence of an island and some shoals in the vicinity of Falcon Island, Tonga group; Positions of the islands Smith, Bayonnaise, and Aoga Sima, Japan; Battle post.

No. 12. Extract from the report of the commander of H. M. S. Olga. Voyage from Apia to Singapore. Extract from the log of the German bark Brazileire. Voyages between the Marshall and Caroline islands. Remarks about the island Butaritari, Gilbert group. Voyage from Yokohama to Hakodate during summer months. Tidal wave in the Pacific, March, 1888. Disappearance of Pelorus reef in the Pacific. Soundings in the Atlantic ocean near the Antilles. Quarterly weather review of the German Observatory. Movements of German naval vessels during 1888. Minor notices: Desert winds at Port Natal; Use of oil at sea; Variation, declination and force of earth magnetism on the coast of California; Remarks on the harbors in Murray Sound, southwest coast of Corea; Specific gravity of sea-water at the mouth of the Congo. Literary review. Spelling of geographical names. E. H. C. L.

THE ENGINEER, NEW YORK.

November 17, 1888. Liquid fuel.

Of course, the war navies, which are not so dependent on prices as the merchant marine, will reserve their verdict until they see, after the termination of the experiments still going on in England, Russia, and France, whether the much-vaunted superiority of oil over coal is justified by the result. Should this be the case, as is probable, these nations, and perhaps the United States, will possibly introduce liquid fuel on their torpedo-boats. Further, liquid fuel, if Laval's experiments prove to be practicable, will very probably be adopted for submarine vessels to an important extent, and finally, it is very possible, as indeed has been the case recently in North America, that liquid fuel will find adopters among the proprietors of pleasure yachts, for in all these cases economy is only a secondary consideration.

December 1. Cellulose.

In the last report of the curator of the Nilgiri Gardens, attention is drawn to a new use for fiber of cocoanuts. The method of proceeding was to take a quantity of the powdered refuse before it was quite dry and subject it to pressure, when the natural viscidity of the macerated cellular substance of the nut caused the whole to cohere and to form a plate, which in general appearance was like a mill-board, only much more brittle. Owing to the hygroscopicity of this substance, if a hole is made through it, the parts adjacent to the puncture absorb water, swell up, and immediately close the orifice. Dr. Lawson got a sack of this refuse and made a plate 18 in. square by about ¾ in. in thickness, which he placed between two boards, and then fastened it to one side of a box which contained a head of one foot of water. A bullet half an inch in diameter was fired through it, but not a drop oozed out. This experiment was repeated three times with the same result. Then a ¾ in. bullet was fired through the plate, when a few drops only made their way through. Lastly a bullet nearly 1 in. in diameter was fired through the plate, when a large jet of water shot through, but in the course of a few seconds the stream decreased in volume, and in less than a minute had ceased to flow altogether.

DECEMBER 15. New floating battery.

It will be a steel ship of the monitor class, of 4200 tons burden, double turreted, and fitted with all the latest improved appliances. The designs for the ship were made in the Bureau of Construction and Repair. She will have a battery of four guns—two sixteen-inch and two twelve-inch—the largest ever made in this country. The amount originally appropriated was $1,000,000, but by a provision of the bill, the final cost of the ship, exclusive of armor, should not exceed $2,000,000, and the material used in the structure shall be, so far as practicable, of American production, and furnished and manufactured in the United States. R. W.

DEUTSCHE HEERES ZEITUNG, BERLIN.

NOS. 1 AND 2. The changes in the past year. Rapid-firing cannon in action in the field. Naval matters. Establishment of quarters for the First Torpedo Detachment on board the condemned armor-clad Hanso, at Kiel. Sale of the condemned German gunboat Dracke. Spain: Summary description of the Spanish electric submarine boat, named after its inventor, Lieutenant Peral.

NO. 3. Bayonet tactics for the infantry. Naval matters. Occurrences at Samoa. Revision of the mustering regulations of the German Maritime Conscription. Italy: Proposed enrolment of vessels of the merchant marine as a reserve for the Italian Navy. Trials of the machinery of the new Italian ironclad Ruggero di Lauria, at Naples; speed, 16 knots; 7500 h. p.

NO. 4. List of officers on the German men-of-war at Samoa.

H. M.

LE JOURNAL DU MATELOT.

NOVEMBER 3, 1888. Violations of the laws of navigation and fisheries, and their measures of repression.

This valuable paper is continued in the following Nos. 45, 46, 47. Nos. 49, 50, 51 contain a notice on Admiral Jauréguiberry.

MÉMOIRES DE LA SOCIÉTÉ DES INGÉNIEURS CIVILS.

SEPTEMBER, 1888. A sketch of the life and work of Henri Giffard (Giffard prize, 1888).

OCTOBER. A memoir on the calculation and construction of air and hydraulic presses, by M. Barbet. Aerial locomotion.

NOVEMBER. Lemoine's funicular brake adopted by the French Government, for the field artillery service, after many years' experimenting. Notes on firing charges in mines in the presence of firedamp. J. L.

MITTHEILUNGEN AUS DEM GEBIETE DES SEEWESENS.

VOLUME XVI, NO. 11. The English fleet manœuvres of 1888. The Italian fleet manœuvres of 1888. The English steamer City of New York. Twin-screw torpedo-boat. The submarine boats Gynmote and Peral. New dynamite gun. Guns for the English Government. The largest existing rapid-firing cannon. Proposed Don-Volga canal to connect the Black and Caspian seas. New torpedo-boats for England, Germany, and Roumania. Armament and names of the new English torpedo-gunboats, type Sharpshooter. A new cruiser and new sloop for the English Navy. Engine trials of the English armor-clad Sans Pareil. American cruiser Baltimore. Launch of the cruiser Sperber, of the Imperial German Navy. Torpedo-boats of the 2d class for Russia. Launch of the Danish cruiser Valkyrien. A new method for improving steel. Literary reviews. Repairs of the bottom of the French transport Shamrock. E. H. C. L.

NORSK TIDSSKRIFT FOR SOEVAESEN.

SEVENTH ANNUAL SERIES, NO. 1. Discussion of the new types of war-ships. The English naval manœuvres in 1888. The Berdan torpedo. New motive-power by vapor. Nordenfelt's electric dirigible torpedo-boat. Changes of engines to triple expansion system. Trial of the forced draught system on board the British cruiser Orlando.

NO. 2. Measures for avoiding collisions at sea. The Monitor type of battle-ship. Results and lessons drawn from English naval manœuvres of 1888. Speed of the English cruisers. Smokeless gunpowder. Value of petroleum for liquid fuel. The English experiments with melinite shells. The American log timber-raft. Sales of English war-ships Warrior and Minotaur.

NO. 3. Measures for improving safety at sea (continuation from last number). Speed as a factor in naval warfare. Thornycroft's new water-tube boiler for torpedo-boats. New type of gunboats of 1st class (Norwegian). Use of oil at sea. English Admiralty regulations for ventilation of coal bunkers. Progress in English naval ordnance. Practice with rapid-firing guns at night. Reorganization of the German Admiralty. German Schwartzkopf torpedoes. German torpedo-boats. Lessons taught by the British naval manœuvres, 1888. German pneumatic dynamite gun. Repairs of old English ironclads. The Italian cruiser Piemonte. Trials of the Italian armored vessel Lepanto. Machinery of the Italian armored vessel Sardegnas. E. H. C. L.

REVISTA MILITAR DE CHILE.

NOVEMBER, 1888. Rapid-fire guns (editorial), by Lieutenant-Colonel Don J. C. Salvo. Statistics of target-firing, by Colonel Jorge Wood. Necessity for reform in the organization of cavalry, and the functions of this arm of the service on the field of battle, by Captain Don A. Fuenzalida. Notes on firing (continuation), by Sergeant-Major Don A. Wilson. J. B. B.

REVUE DU CERCLE MILITAIRE.

OCTOBER 28, 1888. Structural forms of the earth's surface (Geography). Operations of the Russian army in the field (continued). The new Italian regulations, setting apart certain civil employments in favor of honorably discharged non-commissioned officers of the army and navy. The Russian manœuvres at Elisavetgrad. Emigration from Alsace-Lorraine to avoid military duty. Trials of a new armor plate at Portsmouth.

The novelty of the armor consists in the fact that the front plate is composed of 12 separate pieces of extremely hard cast steel of 6 mm. in thickness, secured to the back by a special process; this back is formed of a single piece of soft cast steel 190 mm. in thickness, keeping the whole together. The idea is that if a projectile strike one of the hard front pieces, the injury will be confined to the piece struck, thus preventing the cracks extending over the whole surface. It is expected that the process, after being perfected, will give good results.

NOVEMBER 4. Determination of the point of attack in battles. Planned and unforeseen battles. Structural forms of the earth's surface. Organization of the Russian army in the field. Target-shooting associations in general. Swiss federal target-shooting.

NOVEMBER 11. The bayonet as a weapon of modern warfare. Battery instruction in the French corps of artillery. The Russian army in the field.

NOVEMBER 18. Regimental schools in the French infantry. Schools of cadets in Austro-Hungary. The Russian army in the field. (This very interesting article is concluded in this No. See Nos. 42, 43, 44, 45 and 46 of the *Revue*.)

NOVEMBER 25. The new organization of foot chasseurs in the French army. Regimental schools in the French infantry (ended). The British native Indian army. Schools of cadets in Austro-Hungary.

DECEMBER 9–16. Retreat of the 13th corps (Vinoy) from Mezières to Laon (September 2 and 3, 1870). The new German drill regulations of September 1, 1888.

DECEMBER 23. The French naval school; life on board the Borda (schoolship). The blood-horse in the French army. Increase of the German artillery.

DECEMBER 30. The use of the telegraph in time of war. The army and navy exhibit at the Universal Exposition of Barcelona.

Organization of the Italian militia for active duty in the field. The Krupp's establishment. Competitive trials of different repeating rifles at Beverloo (Belgium).

JANUARY 6, 1889. New instructions regulating the opening of fire of field batteries. Naval architecture: I. The wooden age; II. The iron age (Historical notes). Military balloons.

JANUARY 13. New regulations concerning tactics in France. Naval architecture: II. The iron age (continued). J. L.

REVUE MARITIME ET COLONIALE.

NOVEMBER, 1888. Collisions at sea—Part II: Running lights and regulations to avoid collisions at sea, with an appendix to Part I, by Commander Banaré. Account of a scientific mission to Cape Horn, 1882–1883 (continued). A historical sketch of chronometers; their care and supply in the French naval service, by Rollet de l'Isle, hydrographic engineer. Reorganization of the German Admiralty. Swimming costumes for torpedo-destroyers (men) in use in the German Navy. Institution in aid to widows and orphans of British merchant sailors. Directing the fire of rapid-firing guns in night attacks. The invisible fire and noiseless gun. The new Armstrong rapid-firing gun of 4.6 inches (36-pounder). Trials of the armored vessel Sans Pareil. Launching of the cruiser Melpomene. Construction of Spanish cruisers of 3000 and 7000 tons. Plans of a U. S. turreted monitor. North Atlantic currents. German deep-sea torpedo-boats.

DECEMBER. Collisions at sea—Part II: Running lights and regulations to avoid collisions at sea, with an appendix to Part I, by Commander Banaré (with numerous illustrations).

This all-absorbing topic of the day is concluded in this number. Since more than ever all maritime nations are interested in seeking the means of avoiding collisions at sea, or at least in perfecting a system of lights that will be of some help to the watch-officer during dark nights and in thick weather, when colored lights are so difficult to distinguish, we would like to offer the following simple method, so simple in fact that it is perhaps the reason it has never been proposed before, though in use on board of a few merchantmen. We will call it the "two white lights system." It being admitted that white lights are perceived from a greater distance and far more distinctly than colored lights, it is proposed that all vessels using steam carry a white light forward of the mainmast, at a height measuring just half the distance between the deck lights, and that at the foremast head both lights to possess the same brilliancy, and both invisible aft. The side lights to be still maintained, but rectangular and three feet high, with the usual width. With the two white lights the position of the vessel in sight can be determined without a possible mistake at all distances and in all kinds of weather (except in case of very thick fog). In the first place, if the lookout sees the mainmast light to the right of the foremast light, the stranger presents his port side; in the second place, if the mainmast light is to the left of the foremast light, the vessel in sight presents the starboard side. If both lights are seen in a line, the ships are advancing end on. The above seems simple and practicable. (Le Vieux Corsaire).*

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*Lieutenant F. F. Fletcher, U. S. N., treats of this subject in a paper entitled "Range Lights on Seagoing Ships," Vol. XII, No. 4, of the Proceedings. He places both lights forward of the foremast, so that the after one will not be hidden when head on, a point which appears to have escaped Le Vieux Corsaire.—EDS.

Affairs in the East (1839–1840–1841), from the diary of a naval officer serving on the Levant station. Care and supply of chronometers in the French naval service, with a historical sketch. Historical study of the French Navy under the administration of Colbert. Tourville and the state of the Navy in his day. Naval manœuvres, and the situation of the Italian Navy in 1888. New organization of British naval divisions. The armored battle-ship Howe; her battery. The armament of the Penelope. The engines of the armored vessel Thunderer, etc. Asphyxia caused by the water-tight compartments of iron ships. List of works addressed to the *Revue*.

JANUARY, 1889. Telemeters of depression.

The object of the present article is to give a description of the instruments (they are of two kinds, the horizontal and the vertical), and to explain their workings in the various circumstances of coast defense in which they may be used, together with the favorable reports on the same of the trial committees.

Historical studies of the military marine of France. Fleet operations under the administration of Colbert (continued). A new rain gauge. Continuation of the article on Tourville and the French Navy of his time, with notes, letters, documents (1642–1701). Military organization of the expeditionary corps at Massouah. Affairs of the East (1839–1840–1841), from the diary of a naval officer attached to the Levant station (ended). Scientific mission to Cape Horn, 1882–1883 (continued). Foreign chronicle: Firemen and stokers on board British steamers. Manufacture of coal-dust bricks for fuel; The electric boat; Internal navigation in Russia; Torpedo-boat practice and evolutions in Spain. J. L.

RIVISTA DI ARTIGLIERIA E GENIO.

SEPTEMBER, 1888. Considerations on the important question of artillery in fortifications, by A. Bellini, major of artillery. Miscellaneous notes, with plates, charts and tables: Hotchkiss rapid-firing guns of 65 mm. and 10 cm.; The defense of Cherbourg harbor by torpedoes; The employment of mitrailleuses; Experiments in Austria with fulminate of mercury match; The Burton gun.

J. B. B.

RIVISTA MARITTIMA.

OCTOBER, 1888. Italian seamen in the Greek service (Historical notes—continuation), by Od. Tadini. Mobile torpedoes for coast defense, by sub-Lieutenant E. Simion—a study. Statistics on the merchant marine of Italy up to December, 1887. Naval mobilization in the United Kingdom—translation of lecture by Rear-Admiral P. H. Colomb. The Hotchkiss rapid-firing gun of 65 mm.—description of cannon and details of experiments (translation).

NOVEMBER. The centenary of steam navigation (an historical study), by Salvatore Raineri. Cipher systems (from a study by Signor de Viaris, ex-naval officer, published in the *Génie Civil*).

Conclusions of Lord Brassey regarding the recent naval manœuvres of the English fleet (translation). New floating dock at Cardiff (description, with plates, taken from the *Times*).

DECEMBER. The acquisition and loss of Cyprus (historical sketch), by Vice-Admiral L. Fincati. Cipher systems (continuation). Importance of mobile torpedoes in naval warfare (lecture before the R. U. S. I. by Captain Grenfell, R. N.). The development of Austrian colonies; the part taken by the fleet in the work (an abstract of a study on the subject, published in the *Revue International*). Shells charged with high explosives; systems of Graydon and Snyder (translations). J. B. B.

ROYAL ARTILLERY INSTITUTION.

VOL. XVI, NO. 10. Calculation of trajectory of the jubilee shot, fired from the 9.2-inch B. L. wire gun.

This calculation is a combination of Niven's and Siacci's methods, giving excellent results. Elevation 40°; calculated ranges, from 20,000 yards to 21,400 yards; actual ranges, 20,236 yards to 20,210 yards.

NO. 12. Method of observing target practice by means of Watkins' depression range-finder.

Observation party at right angles to line of fire. Instrument measures horizontal angle from point of fall to target. M. K. E.

ROYAL UNITED SERVICE INSTITUTION.

VOL. XXXII, NO. 145. A paper on fast cruisers, by Sir Edward Reed.

Pointing out the serious defects of the unprotected cruisers. Coal too high up endangers stability; at the mercy of shell from guns of any caliber.

Lack of speed of armored ships built by Admiralty.

M. K. E.

TRANSACTIONS OF THE TECHNICAL SOCIETY OF THE PACIFIC COAST.

VOL. V, NO. 4, NOVEMBER–DECEMBER, 1888. The swamp and marsh lands of California, by Marsden Manson. Experiments for determining the relative tensile strength of plain and twisted iron and steel bars, with tables, by Lieut. F. P. Gilmore, U. S. N. R. W.

TRANSACTIONS OF THE INSTITUTION OF NAVAL ARCHITECTS.

1888. The application of hydraulic power to naval gunnery, by Lord Armstrong and Mr. Vavasseur.

This paper shows the great advantages which have resulted from the application of hydraulic power to naval gunnery, and describes some of the mechanical adaptations for rendering it available. Two main classes of hydraulic mountings are described, the first class consisting of carriages from 4 in. to 9.2 in. in caliber, or 1¼ to 23 tons in weight, the hydraulic power being employed only for absorbing the force of the recoil, and for controlling the running in and out of the gun—loading, training, and elevating being performed by manual labor; the second class consisting of carriages for all guns of a larger caliber than 9.2 in., in which all operations connected with the gun are carried out by hydraulic power.

Progress and development of the marine engine, by Frank C. Marshall.

On some recent experiments with basic steel, by W. H. White.

On the present position occupied by basic steel as a material for shipbuilding, by B. Martell.

These last two papers tend to show that good, reliable steel can be made by the basic process, and that in Great Britain it holds at present the position held by steel manufactured by the acid process some years ago. Experience is wanting and great care is needed to produce good results. The advantage gained by using cheaper ores in the basic process insures every effort being made to produce a successful result. In our country the high royalties have kept back the development of the basic process, but good results have been obtained from both basic open hearth and basic Bessemer steel.

On American war-ship design, by W. John.

On unarmored water-lines in war-ships, by Captain C. C. Penrose Fitzgerald, R. N.

The development of modern weapons considered in relation to the designs of war-ships, by Captain Hubert Grenfell, R. N.

The first of these three papers is a description of our battle-ship, the Texas, by its designer, who does not appear to be in love with his own design. He says, "the designer was left more or less free as to water-line protection, but if vertical armored protection was adopted, it had to be at least 12 in. thick." He further says he is one of those who believe in a water-line belt in preference to the internal sloping protection and a fairly deep belt; yet in his design, the vertical armor ends both forward and aft with engine-room bulkheads, and it is a comparatively narrow belt, the fact being that Mr. John, being limited in displacement and obliged to take 12 in. armor, did his best within his limits.

The second paper is by a well known opponent to soft end battleships, and he aims another blow at that class of vessels, while he advocates better water-line protection and the adoption of some water-excluder, such as cellulose, woodite, india rubber, etc.

In the third paper the writer, who is a strong advocate of the gun as opposed to the torpedo, says: "In destructive effect I see the gun equal, if not superior, to the torpedo, and in many other important respects—in area of effect, accuracy, reliability, strength, and simplicity of construction—far beyond it; and I make bold to say that, in my opinion, it maintains these advantages throughout the whole scale of its application, from top to bottom." In the discussion which follows these papers, the design of our battleship is pretty generally condemned by both advocates of water-line and internal protection, but most admit that it is a skillful attempt of a very able architect to fill the requirements upon a limited displacement.

Working and test pressures for marine boilers, by Richard Sennett.

This paper, written by the chief engineer to the Admiralty, is a plea against insisting on too high a factor of safety in the boilers. He says: "This factor, which a few years ago was usually required to be from 6 to 8, has now been reduced in ordinary practice to from 4 to 5, which represents an increase of 40 to 50 per cent in the working steam pressures allowed to be carried with a given thickness of plate. There is, however, a danger, that unless carefully guarded and defined, the factor of safety, even as now modified, may prove a bar to further progress. The present Admiralty rules provide that the stress produced by the water-pressure test shall not exceed four-ninths of the ultimate strength of the shell, so that it shall be well within the elastic limit of the material, and the test may be applied as often as may be desired without injury to the structure. The boiler is therefore designed so that, when subjected to the water-test pressure, the shells have a factor of safety of 2¼." "The working pressure is not, however, now reduced to one-half the water-test pressure, for which there is no good reason, but is fixed at 90 pounds per square inch below the test pressure, which provides ample margin for safety."

On using highly volatile liquids for purposes of propulsion, by A. F. Yarrow.

On the fineness of vessels in relation to size and speed, by J. A. Normand.

On a method of approximately determining the mean girth of ships, by A. Blechyden.

Forced draught, by J. R. Fothergill.

Boilers under forced draught on the closed stokehold system, by Thomas Soper.

In the last two papers and discussion, the advantages of the two systems, the closed ash-pit and the closed stokehold, are discussed.

On the "constant" system of notation of results of experiments on models used at the Admiralty experiment works, by R. E. Froude.

A theory of the screw propeller, by Prof. A. G. Greenhill.

Proposed designs for surface-boats and diving-boats, by Lieut. G. W. Hovgaard, Royal Danish Navy.

The discussion following this paper embraces the rival methods of electromotive power and stored steam power, also the size of scantling for diving-boat.

On the material best suited for propeller blades, by W. C. Wallace.

Notes on the influence of size and speed on collisions at sea, by J. H. Heck. R. W.

UNITED SERVICE GAZETTE.

NOVEMBER 10, 1888. Employment of artillery in masses; its historical development and tactical importance in the battle-field.

NOVEMBER 17. New repeating rifle for Belgian Government, on trial.

Easily dismounted, very simple.

JANUARY 5, 1889. Vertical fire in the field becoming of great importance.

JANUARY 19. Quick-firing guns for fortress defense, of great value as range-finders, and to cope with unarmored cruisers, torpedo-boats, etc. M. K. E.

LE YACHT.

NOVEMBER 17, 1888. Defenses of the military ports of Brest and Cherbourg. The Navy before the Chamber of Deputies. Propelling ships by means of aerial screws. A manual of yacht and boat sailing. Account of the expedition to Cochin-China in 1861.

NOVEMBER 24. The effort required on the part of France in order to complete her naval power. Trials of the submarine torpedo-boat Gymnote in the roads of Toulon. A study of the practical use of the catamaran. Extra-parliamentary inquiry into the workings of the British naval service. The new French four-masted ships.

DECEMBER 1. More about the submarine boat Gymnote (E. Weyl) (two drawings in the next number). The practical development of the catamaran, with illustrations. Our cruisers in distant stations (K...)

DECEMBER 8. The German navy (E. Weyl). Review of the merchant navy of the world. Technical maritime association. The practical development of the catamaran (continued). Drawings of the hull and sails of the Mackenzie catamaran.

DECEMBER 15. A more equitable method of promotion in the Navy desirable (E. Weyl). A study of the practical development of the catamaran (continued). The life-saving exhibition at the Palais de l'Industrie, Paris.

DECEMBER 22. The naval policy of the British Government criticised; more armored battleships and cruisers wanted; a review of other navies. Comparative stability of keel and centerboard yachts. The U. S. armored battleship Texas. Illustrated description of M. Mitchel's permanent log.

DECEMBER 29. An examination into the cause of the bursting of the 34-c. gun on board the Amiral-Duperré (E. Weyl). A review of the merchant marine of the world.

JANUARY 5, 1889. The Navy situation on the first of January, 1889. The scientific cruise of the Hirondelle, Prince Albert of Monaco's steam-yacht. Manœuvring capacity of the Spanish torpedo-boats. Cruisers and armorclads.

JANUARY 12. The "Yachting" at the Paris Universal Exhibition. The Navy before the French Senate. The U. S. Vesuvius.

JANUARY 19. The U. S. Navy (E. Weyl). A new system of torpedo-nettings, by Engineer Solomiac. Nautical instructions for the better protection of the southern coasts of France. J. L.

REVIEWERS AND TRANSLATORS.

Lieut. E. H. C. LEUTZE,	Lieut. A. GLEAVES,
Lieut. J. B. BRIGGS,	Prof. JULES LEROUX,
Ensign M. K. EYRE,	Prof. H. MARION,
Ensign J. H. GLENNON,	Prof. C. R. SANGER.

ANNUAL REPORT OF THE SEC. AND TREAS. OF THE U. S. NAVAL INSTITUTE.

To the Officers and Members of the Institute.

Gentlemen:—I have the honor to submit the following report of the affairs of the Institute for the year ending December 31, 1888.

ITEMIZED CASH STATEMENT.

Receipts.

Items.	First Quarter.	Second Quarter.	Third Quarter.	Fourth Quarter.	Totals.
Dues	$801.26	$793.93	$240.05	$353.10	$2188.34
Subscriptions	187.80	250.25	138.10	13.25	589.40
Sales	184.72	283.45	68.48	134.60	671.25
Life-membership fees	60.00	30.00	30.00	120.00	240.00
Interest on bonds	42.76	..	42.76	9.00	94.52
Binding, extra	8.80	4.00	5.00	7.80	25.60
Sundries	.15	7.29	..	..	7.34
Totals	$1285.49	$1368.82	$524.39	$637.75	$3816.55

Expenditures.

Items.	First Quarter.	Second Quarter.	Third Quarter.	Fourth Quarter.	Totals.
Postage, freight, etc.	$50.18	$55.49	$23.60	$28.86	$158.13
Stationery	84.89	46.72	1.63	24.71	157.95
Messenger	75.00	100.00	90.00	93.00	358.00
Branch expenses	40.15	8.32	..	.30	48.77
Extra binding	56.30	19.10	..	..	75.40
Purchase of back numbers	.50	1.00	1.00	7.25	9.75
Prize for 1888	..	..	100.00	..	100.00
Publication	817.40	862.00	..	454.85	2134.25
Rebate on subscriptions	1.57	..	.55	..	2.12
Office expenses	12.74	21.74	..	3.56	38.04
Rebate of dues	..	3.00	3.00	6.00	12.00
Purchase of prize medal	..	33.75	..	..	33.75
Subscript'n Army and Navy Register	5.00	..	..	..	5.00
Purchase of bond	119.50	..	..	..	119.50
Totals	$1263.23	$1151.12	$219.78	$618.53	$3252.66

SUMMARY.

Balance of cash unexpended for year 1887	$151.39
Total receipts for 1888	3816.55
Total available cash for 1888	$3967.94
Total expenditures for 1888	3252.66
Cash unexpended, January 1, 1889	$715.28
Cash held to credit of Reserve Fund	232.62
True balance of cash on hånd, January 1, 1889	$512.66
Bills receivable for sales of No. 47	150.00
Bills receivable for back dues	834.50
Total assets, January 1, 1889	$1497.16
Bill outstanding for No. 47	

RESERVE FUND.

List of bonds deposited for safekeeping in the Farmers' National Bank of Annapolis, Md.

United States 4 per cent registered bonds	$900.00
District of Columbia 3.65 per cent registered bonds	1000.00
District of Columbia 3.65 per cent coupon bonds	850.00
Total face value of bonds	$2750.00
Cash in bank uninvested	232.62
Total Reserve Fund	$2952.62
Annual interest on bonds	103.53
Number of new life members	8

During the year one District of Columbia bond, 3.65 per cent, was purchased for $119.50.

MEMBERSHIP.

The membership of the Institute to date, January 1, 1889, is as follows: Honorary members, 7; life members, 94; Regular members, 593; associate members, 168; total number of members, 862, giving an increase of 31 members since March 1, 1888.

List showing increase of members since 1879, prior to which date there is no record:

Year.	No. Members.	Increase.	Year.	No. Members.	Increase.
1879	267	...	1885	763	77
1880	382	115	1886	769	6
1881	481	99	1887	787	18
1882	506	25	1888	831	44
1883	591	85	1889	862	31
1884	686	95			
	Total increase since 1879				595

PUBLICATIONS ON HAND.

The Institute had on hand at the end of the year the following copies of back numbers of its Proceedings:

	Copies Plain.	Copies Bound.		Copies Plain.	Copies Bound.
No. 1	203	...	No. 25	1145	42
2	247	...	26	207	77
3	64	...	27	293	27
4	154	...	28	4	...
5	127	...	29	225	27
6	10	...	30	257	2
7	16	...	31	59	54
8	42	...	32	...	174
9	46	...	33	14	164
10	7	...	34	59	10
11	220	...	35	103	66
12	61	...	36	248	25
13	5	...	37	170	21
14	7	...	38	248	2
15	2	...	39	248	2
16	224	...	40	28	111
17	4	...	41	249	16
18	96	...	42	134	13
19	114	...	43	289	3
20	130	...	44	276	10
21	234	...	45	218	18
22	279	...	46	226	18
23	180	...	47	213	18
24	201	...			

4 Vol. X., Part 1, bound in half morocco.
1 “ “ 2, “ “ “ “
1 No. 34, “ “ “ “
1 Vol. XI., Part 1, “ “ “ “
1 “ “ 2, “ “ “ “
1 Vol. XII., “ 1, “ “ “ “
1 “ “ 2, “ “ “ “
1 Vol. XIII., “ 1, “ “ “ “
2 “ “ 2, “ “ “ “
8 No. 34, “ “ full sheep.
“ 34, “ “ half calf.

The archive set complete, Vol. I. to Vol. XIII. inclusive, bound in full turkey.

INCOME.

Members paying dues, 761, at $3	$2283
Interest on bonds	103
Regular subscriptions and sales	779
Total	$3165

In addition to this amount there is an uncertain sum collected from back dues and from sales of whole sets and single numbers, also amounts paid for binding. The expenses last year, deducting amount paid for bond, were $3133. In view of the small margin between receipts and expenditures, the Board of Control has decided to publish in the Proceedings advertisements of inventors and manufacturers of material of war, and they hope that, through the exertions of the friends of the Institute, a regular sum may be added to the income from this source that will enable them to increase the value and interest of the Proceedings to its readers. The circulation is now about 1200 per quarter.

All business communications should be addressed to the Secretary and Treasurer U. S. Naval Institute, Naval Academy, Annapolis, Md., and all postoffice orders, checks or drafts should be drawn in favor of the Secretary and Treasurer. The use of the name of the occupant of the office is liable to create confusion, as it may be some time after a change has taken place before the more distant correspondents become advised of the fact.

Very respectfully,

RICHARD WAINWRIGHT, *Lieut., U. S. N.,*
Secretary and Treasurer.

ANNAPOLIS, MD., *January* 1, 1889.

THE PROCEEDINGS
OF THE
UNITED STATES NAVAL INSTITUTE.

Vol. XV., No. 2. 1889. Whole No. 49.

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.
APRIL 11, 1889.
COMMANDER P. F. HARRINGTON, U. S. N., in the chair.

OUTLINE OF A SCHEME FOR THE NAVAL DEFENSE OF THE COAST.

BY CAPTAIN W. T. SAMPSON, U. S. N.

The many who during the past years have been discussing publicly the subject of the defenses of our coast agree in this, that of adequate coast defense our lack is absolute and our need imperative. This is particularly true of naval defenses, so that the subject is of peculiar interest to the naval officer. And, although the professional opinions of the service have not yet received the attention that I think they merit, this does not the less make it the duty of the service to express its opinions untiringly, and to see that these opinions are based upon sound and thorough professional knowledge.

In these days of curious inventions, when every year discovers some new scheme or engine of war which its sanguine inventor is sure will supersede all others for the defense of the coast, it is the duty of the profession to consider carefully such schemes and inventions, and assign them their proper weight and place. With all the zeal and persistence born of prospective gain, each in turn will be urged; and, while professional opinion should possess sufficient flexibility to recognize and accept what is good in each, it should also possess fixed principles and a guiding policy to enable it to reject what is worthless, and prevent it from distracting public attention from public needs. This is, indeed, the worst evil we have to contend with. Some enthusiast proposes to defend our coast with torpedoes; another proposes to destroy the iron-clad fleets of our enemies with air-guns; while others rely upon the patriotism of the country when need shall come. Each of these is good, but all of them together would prove insufficient, and this we should be prepared to demonstrate, and to point out what is needed.

We are now building a new navy; we are taking the first steps towards providing proper forts and guns, and we should see that the sound policy that has prevailed for some years past in the building of our ships should be developed and extended to the more important needs of the service as represented in armored ships.

In the matter of coast defense, this nation has been for thirty years at a standstill, while others have been steadily advancing, so that now we find ourselves far in the rear. Thirty years ago the plans in progress for home defense were quite equal to those of any other nation; and though the numbers of our forts and ships were insufficient for the defense of our coast, both were in quality excellent. Our forts were of the most approved construction, some of them possibly upon too large a scale and unnecessarily expensive; while for our ships and their armament, they were without superior. The rebuilding of our navy has been slow, because the use of steel for naval ships is a new industry; but under the stimulus produced by the demands of the naval service, the capacity of our ship-yards, both public and private, will be rapidly increased, and production of material and experience in its use will quickly accumulate.

As the construction of ships becomes more rapid, it is more necessary that their character should be carefully considered, lest serious mistakes be made. The wants of the government should be thoroughly understood, and all the energies of the nation that are to be expended upon preparation for war should be given the right direction. That the defense of our coast is the most important end to be secured, no one will question, for the first care of any nation is to secure its integrity and, at the same time, to furnish proper protection for the lives and property of the people. Without this, accumulated wealth serves but to tempt the cupidity of more powerful nations, and every advantage of thrift and high civilization may, on slight pretext, vanish, or become the possession of a more war-like people. Should our nation continue to increase in wealth and population as it has done in past years, it is sure to become the envy of less favored nations, who will not hesitate to take advantage of any opportunity to humiliate us. We have only to look back at the time when internal strife permitted a foreign nation to avail itself of our distress to gain a foothold where, under less favorable circumstances, she would not have ventured. Had this enterprise succeeded, can we doubt that other nations would have been prompt to claim a share of our dismembered country? There would not have been wanting good reasons for such action. England could not see France acquiring territory in the western hemisphere without doing the same, in order that the balance of power between them might not be disturbed. And at the present time at least one other powerful nation would be actuated (under like circumstances) by similar motives.

It is difficult to see now in what manner or from what causes the integrity of the nation may be again jeopardized as it was in 1861; but we should remember that the danger to our country from foreign foes was great during that memorable struggle. A country torn by internal strife becomes an easy prey to envious foes—foes who during prosperity were warmest friends. History shows too plainly that even Christian nations who uphold the most advanced ideas of international law do not hesitate to disregard its plainest rules when the seeming prosperity of their country may be advanced thereby; and it is all done in the name of civilization and for the best good of the victims. While we all sincerely wish for the time when international disputes shall be settled without bloodshed, let us not be misled by the rose-colored representations of those who advocate arbitration as a means of settlement. In order to insure the success of arbitration, let us be prepared with other means in case of its failure.

In order to decide upon the means necessary for the defense of our coast, we must first examine and determine as far as possible against what we may have to defend ourselves. The sources of danger may be conveniently divided as follows:

1. An attack upon our commerce afloat. I venture to consider this question as properly included in the attacks to be guarded against in coast defense, because it would be unwise to provide a scheme of naval defense that was not calculated to protect also our ocean-borne commerce; also, because with an extensive commerce it would

be the first and easiest form of attack, and as we shall see, can be accomplished in several ways, one being a blockade of our commercial ports, which should be provided against in any scheme of coast defense.

2. Immediate blockade of our defended ports.
3. The bombardment of our sea-coast cities.
4. Invasion by an armed force, probably under the protection of a naval force.

Let us examine the probability of these four cases, taking them in reverse order. The probability of an invasion from any nation is very remote. The great distance by water that separates us from any probable enemy is our best defense, and a sufficient one if we exercise even moderate caution. To examine more closely the conditions of this case, we shall see that the transportation of even a moderate-sized army of, say, 150,000 men to our shores would be a vast undertaking. Any European nation would require at the rate of 4000 tons of shipping for the transportation of every 1000 men and their equipments. To transport an army of 150,000 men would require a fleet of 200 steamers of an average tonnage of 2000 tons each.

The force sent by England to Cyprus in 1878 consisted of 8600 troops and followers, with horses and guns, and required 28 ships of 57,000 tons. The force sent by England to South Africa in 1879 was 8100 men of all ranks, with horses and wagons, and required 53,000 tons of shipping. The troops sent out to Mexico in 1861-63, under Maximilian, amounted to 38,500. In August and September, 1862, 20,000 were sent out under 5 convoys.

The above-mentioned fleet of 200 ships would be required for the transportation of such an army of 150,000 men and their maintenance for the period of two weeks, barely sufficient time to cross the ocean. As they must land upon a hostile coast, where they would be forced to depend upon the home base for a food supply, it may readily be seen that the fleet of 200 transports would have to be greatly increased. With a population of 60,000,000 from which to draw for defense, with ample internal communication for the concentration of the defense, the invasion of this country presents an undertaking of such magnitude that we may dismiss it, except in one case, from the list of probable forms of attack. The one exception referred to is that of a difficulty with England. It is readily seen that Canada would, in this case, become a base of operation which would give an invading army ample resources, while with a powerful fleet, reinforcements and ammunition could be easily transported. In such a case, our main reliance would be upon our own army, and the case would not, therefore, be properly included in a discussion on the naval defense of the Atlantic coast.

3. The bombardment of our sea-coast cities. Here it is necessary that we should first settle to our own satisfaction whether an unfortified, unresisting city may be bombarded. Those writers on international law who mention the subject lay it down as an acknowledged rule that an unresisting city may not be bombarded. In this matter it is certain that a broad distinction exists, which has not been recognized by writers upon this subject, between the bombardment by an army and a bombardment by a naval force. In the case of an advancing army, it appears most reasonable that it should not bombard a city which offers no resistance; for the army has only to take possession. To bombard under such circumstances would be not only useless, but inhuman; all right-minded people justly condemn it.

The case is quite different, however, when it is a question of the bombardment of an unresisting city by a naval force: it being understood that resistance would be offered if the naval force should land to take possession. The naval force has the power, as had the army, to inflict injury upon the city and compel compliance with its demands, but in a different way, and this difference in the form of the force involves a modification of the international rule when applied to bombardment by a naval force.

Upon this point, Calvo, a French authority on the law of nations, says: "In no case, under no pretext, is it permitted to bombard an open unfortified city which is not defended by military. To act against such places as the necessities of war authorize to be done against fortresses is to violate all the laws of nations, and to place one's-self outside the law of those nations which march at the head of civilization.

"Among the modern cases of this kind which have most awakened public attention may be cited the bombardment of Valparaiso in 1866, by the Spanish squadron under the command of Admiral Mendez-Nunez, which constitutes a deplorable precedent of the application of force as a means of resolving an international question."

Further, upon this subject the same author cites several cases where the attack upon fortified cities was directed upon the fortifications and other defenses and not upon the city itself, and commends this mode of proceeding as causing less bloodshed. This is, however, questionable, and in strong contrast to the business methods inaugurated by Farragut, who passed the fortifications and brought the cities directly under the guns of his fleet. In these cases it cannot be said that the bloodshed was increased.

The manœuvres of the British fleet during the past summer led to a very animated discussion, both in the press and in Parliament, upon the question of bombarding undefended cities. All naval and military authorities agreed that it was a kind of warfare likely to ensue in case of hostilities, and that it should be prepared for; while others declared that the rules of civilized warfare forbade such bombardment, and some even went so far as to declare that such cities as Greenock would require no defenses, that it would not be molested by any probable enemy. Unfortunately it cannot be assumed that such opinions were not, to some extent at least, biased by political views. Those in England who think that the navy should be increased took one view, while those opposed to any material increase in the naval force, whether from economical reasons or from opposition to the government, were led to adopt the view that would require the least preparation for defense.

One English authority on international law quotes the rules laid down by the military delegates of all European states to the Brussels Conference in 1874, and says that with the necessary changes in wording, these rules apply to the operations of naval forces against places on land.

The rules that interest us at this time are as follows:

"Art. 15. Fortified places are alone liable to be besieged. Towns, agglomerations of houses, or villages, which are open or undefended, cannot be attacked or bombarded.

"Art. 16. But if a town, etc., be defended, the commander of the attacking forces should, before commencing a bombardment, and except in the case of a surprise, do all in his power to warn the authorities."

As before explained, the rule here laid down in Art. 15 is for land forces, and requires material modification before it can be made applicable to a naval force. It is more than likely that the commanding officers will receive specific instructions covering all doubtful cases; the Spanish admiral was so instructed in the case of Valparaiso.

A city may be defended by armed men only, and consequently be totally unprepared to resist a naval attack; or it may even be fortified to prevent the approach and landing of a naval force and yet be exposed to destruction by bombardment. No restriction can be placed upon a naval force in either case to prevent bombardment. If such a city refuses to comply with any reasonable—even though exorbitant—demands made upon it, it lays itself liable to bombardment by an enemy having the power to inflict such a punishment. On the other hand, I think it may safely be stated as a rule that a naval force intending to bombard a city must give ample warning of its intention, and if anticipating the approach of succor, must abandon its intention rather than attack without such warning as will permit the escape of women and children. Even should the object of the bombardment be to destroy military or naval depots, it cannot be done without warning, if the lives of non-combatants would be endangered thereby. I also think that a notification of intention to bombard can be given only when the naval force is present. It would not be considered proper warning should an enemy telegraph along the coast or to any particular city that it would be bombarded on a specified date.

Many rules of international law are deliberately violated when it appears to advance the interests of the violator and there is the necessary power to brave the consequences. It is for this reason that the protection offered by many of the wise and humane rules of international usage are not to be relied upon.

But this rule, that a city shall not be bombarded without due notice which will permit women and children to be removed beyond possible injury, is a rule no civilized nation would venture to disregard. During the manœuvres of the British squadron the past summer, the Irish squadron eluded the blockade of their English enemies, and engaged in a raid upon the English coast, bombarding Greenock, Liverpool, and other unprotected cities. Greenock harbor was entered by a single vessel one Sunday morning and bombarded immediately, without any communication with the shore and while the people were at divine service. This does not represent actual warfare, because no commander would bombard an open city without first making a demand for a ransom or the fulfilment of any conditions he might see fit to impose. No impossible demand should be made, with the alternative of bombardment in case of refusal. Reasonable time must be granted for a reply, and, in case of refusal, further delay must be granted to permit non-combatants to leave the city. A large sum of money, for example, cannot be produced at a moment's notice, and such transactions must be conducted upon a strictly cash basis. The citizens would doubtless request a modification of the demands, all of which negotiations would require time. This could not be refused by the commander, except in cases of extreme necessity involving the safety of his ship, and even then he would have to face the execrations of the whole world for his inhumanity. In any case, more time would be consumed than ten hours, which was permitted by the English rules.

We shall see that this has a very important bearing upon the naval defense of a city. The time element that the rule involves furnishes a great advantage to the defenders. The modern practice regarding bombardment of unfortified cities, as in the case of Valparaiso, is directly opposed to the international rule against it. At the same time, the popular conviction of what would take place in event of a foreign war is in harmony with the views expressed above.

If further argument were necessary to show that an unfortified city may be bombarded by a naval force, it may be found in the statement that if bombardment is not permitted under such circumstances, then complete protection is to be had by non-resistance. An unfortified city that offers no resistance to a naval force would be exempt from molestation, because the naval force when landed would be too insignificant to contend with the land force that would then be developed to oppose it. When a fleet has made a demand for a ransom upon an unfortified city and the ransom has been refused, the fleet cannot be expected to abandon its position of advantage, its power as a fleet, and land its men and attempt to take by a landing party what was refused to the fleet. If such a construction could be put upon the general rule that unfortified cities may not be bombarded, then it would become absurd, and in coast defense naval supremacy would have no significance. We may then consider it settled beyond a doubt that our coast is liable to this form of attack, and, as we shall see, will be one of the principal forms against which we have to provide.

2. Immediate blockade of our defended ports. The defenses here referred to include all means of whatever nature that are sufficient to deter the enemy from a direct attack. These defenses may be forts, submarine mines, or other obstructions, or floating defenses. If any of these, or a combination of them, is sufficient to deter the enemy from a direct attack, and it is decided to act against the city in question, the next form of hostilities would be to blockade

the port. The object of this blockade may be to close a port that contains an important dock-yard, and prevent access to it by our own ships; or it may be to confine within the port our own armed vessels that may have assembled there; or it may be for the purpose of interrupting and destroying the commerce of the port. In order that an enemy should resort to blockade, instead of direct attack, of any of our ports, it would not only be necessary that the means of defense were sufficient to make the result of an attack doubtful, but the defenses must be so placed as to prevent the direct bombardment of the city. If the enemy could destroy by bombardment, the city, the shipping, or the naval depots that might be its object of attack, without the necessity of overcoming the defenses, then this mode of attack would be resorted to as being more certain and expeditious, and an extended blockade would be unnecessary.

It is, of course, understood that while the forms of attack to which our coast is liable may be classified for convenience of discussion under the four heads above mentioned, at the same time the attack may take the form of a combination of these, and bombardment or blockade may be preceded by, or at any time interrupted by, an engagement with our fleet. At the commencement of hostilities, the enemy might be only prepared to interrupt our commerce with a few fast cruisers, and as other vessels were prepared for sea she might commence an off-shore blockade with the same class of vessels, this being a more effective way of destroying our commerce, as her ships would then be at the points of convergence or foci of our trade.

This form of attack might soon be replaced by a close blockade or bombardment when more powerful vessels had concentrated upon our coast. The character of the attack could be anticipated with considerable certainty from a knowledge of the naval force at the command of the enemy and its degree of preparedness. An enemy with an overwhelming naval force prepared for active service upon short notice would be able to inaugurate all these forms of attack at once, and at several points of our coast. An enemy with a smaller fleet, or less prepared for immediate action, would adapt her course to the means at her command, and, as an example, blockade the port of New York, while leaving free a sufficient force to meet our own fleet. If the disparity between the naval force of the enemy and our own were still less, then hostilities would take the form of an attack upon our commerce on the high seas, while exposed and undefended points of our coast would be threatened by small squadrons or single vessels, with the object of distracting our own naval force and keeping it at home. Doubtless a very insignificent naval force could do much towards driving our commerce from the sea, but it is only from a superior naval force that we have to fear ultimate destruction of our own.

This is a fact that deserves most careful consideration, and from it the gravest lesson should be learned. When war ships were built of wood and propelled by the wind; when a month was sufficient to construct both ship and armament; when the slow and uncertain movements of a ship and the insignificant injury produced by her projectiles prolonged wars and gave time to build fleets, then it was not proper to measure the naval power of a nation by the number of ships afloat. But her wealth and resources and ability to add to her fleet were important factors in the problem. Now, when a modern man-of-war has become the most complicated machine that the brain of man ever devised; when careful training and much experience are necessary in those who man the ship; when years are required for her construction; when her powers of destruction have been increased many-fold; when the celerity of her movements has reached the certainty and speed of a railroad train, we have reached a point when naval warfare will be of short duration, and it will be impossible to add materially to the fighting fleet after hostilities have commenced.

The conditions are the reverse of what they were less than fifty years ago. Notwithstanding the vastly increased constructive skill and resources of modern times, it requires much longer to build a ship than was required fifty years ago; but when completed, her warlike power permits no comparison with the ship of half a century ago. It therefore results that national wealth and resources will have a minimum influence upon the result of future naval wars. After war has been once declared, that nation which is best prepared for immediate action will force the fighting and bring it to a speedy termination.

The lesson we should learn is, that preparation for war which is deferred until war is imminent will result in certain defeat. We might console ourselves with the thought that in a few years we could certainly take our revenge, and I do not doubt that this thought would have a powerful influence to deter any nation from attacking us. A prudent enemy would, certainly, count the cost and see in the not distant future that a nation with such vast wealth, unlimited resources, and a population unsurpassed in mechanical skill and enterprise, would be likely to retrieve any present loss. Although this skill and enterprise is now directed to peaceful pursuits that constantly add to our wealth, yet there can be no doubt that the skill which can devise such endless number of labor-saving machines could also produce the most effective engines of warfare if called upon to do so. But is it wise to trust our national security to the potential energy of our people? Would it not rather be the part of wisdom to provide ourselves with such defenses as will, for the moment, deter any nation from quarreling with us, and thus render the nation secure for all time? No right-thinking man would advocate such an armament as would lead the nation to become arrogant or self-asserting to others. We have no natural enemies, no powerful neighbors who must be watched to prevent encroachments upon our territory. But, as it is impossible to see what the future has in store for us, it is only prudent to look to the past for guidance, and see how various and unforeseen are the causes that lead to war.

Nor is it impossible to read the future so far as to divine the probable course of events near at hand; and I venture to assert that the time is not far distant when we must relinquish some of our recent applications of the Monroe Doctrine, or be prepared to defend them with our guns. In the maintenance of this principle we are soon to touch the vital interests of European nations. When the canal across the isthmus is completed, every commercial nation of the earth will find, by this way, a shorter route for much of its commerce. When any two of these nations become involved in war for any reason, the one that has the most powerful navy will attack the commerce of the other, and one of the most promising points of attack would be where the lines of trade converge to this canal; or one party to the conflict may find it a military necessity to close the canal against the other.

What will be our course under such circumstances? Are we prepared to maintain the neutrality of the canal? It must be remembered that when the Monroe Doctrine was first promulgated (65 years ago), it was not admitted by any European nation as a rule to control its action in the future; on the contrary, it was distinctly repudiated by England, whose interests at that time would have naturally led her to accept it. This being the case, can we expect that the modern extensions which have been given to the principle will be more acceptable? We have grown mightily in strength in

65 years, and are better fitted to maintain the views we hold upon this subject than we were at the time it was promulgated, but this does not change the acceptability of the principle to foreign nations. Not one of them would consider itself liable to a charge of violating any rule of international right if they disregarded the Monroe Doctrine. Not one of them would be deterred by it from any course of action, except in so far as it would bring upon them the disapproval of this country. It is, therefore, a right that we must maintain by force.

The connection between this subject and coast defense is to be found in the fact that anything which leads to an international difficulty would, at once, put us on the defensive. And it is more than probable that to enforce our rights in this hemisphere, as those rights are now defined, would require an enormously larger naval force than is required for the defense of our own coast. And this for two reasons:

First. Because any attempt to enforce the principles of the Monroe Doctrine outside of our own domains (and no other cases are likely to arise) would have to depend upon the Navy; and it would be brought into direct conflict with the whole naval force of our enemy, without the protection of our home military defenses.

Second. Because the principle of the Monroe Doctrine is not admitted by any foreign nation, and it is not improbable that they would combine to make us yield its application in any particular case. We have done so in more than one instance and may be forced to do it again. Happily, the principle of the Monroe Doctrine, which we have set up as a law of our national policy, is one that we will apply in its broadest sense when we can, and yield its application only when we must, but without yielding the principle. It is assuredly in this direction, more than in any other, that we must look for a storm.

Only within a few days, the collapse of the Panama Canal scheme has brought the whole question very close to the line that has been prescribed by our government as the limit beyond which no European government shall go. President Hayes, in his message to Congress in March, 1880, expressed the sentiments of the country upon this subject, and these were approved by Congress and repeated by his successors. He said: "The policy of this country is a canal under American control. The United States cannot consent to the surrender of this control to any European power. The capital invested by corporations or citizens of other countries in such an enterprise must, in a great degree, look for protection to one or more of the great powers of the world. *No European power can intervene for such protection without adopting measures on this continent which the United States would deem wholly inadmissible.*"

The French Parliament has just been asked to do this very thing—intervene to protect the interests of thousands, or possibly millions, of her population who have sums of money embarked in this enterprise. The Parliament has thus far refused to accord such protection, undoubtedly because to do so would bring that country into direct conflict with the United States. But will the popular voice of France sustain this action of her representatives? Certainly France will not permit such a loss to her people without efforts to prevent it—to say nothing of the national pride the country has taken in the success of this great enterprise.

Having taken a hasty glance at the forms of attack that we may expect in case we become involved in war, and having noticed some of the conditions or indirect causes that may bring about war, let us examine for a moment the ability of our possible enemies to subject us to such attack. To those who may read this paper it is not necessary to do more than refer in general terms to the naval power of foreign nations, so great is it in comparison with our own. As we have seen, every form of attack to which we may consider ourselves liable will be inflicted by a naval force, and the ability of any nation to inflict such punishment will depend directly upon her naval strength. An examination of the following table shows that any of the countries named have the necessary force to indulge in one or more of these forms of attack against us. So far as threatening our coast towns is concerned, it may be done by a single cruiser. She might be inferior in speed to many of our own vessels and yet elude them for a long time.

	1st Class.	2d Class.	3d Class.	4th Class.
Great Britain,*	160	40	95	35
Austria, ...	21	9	12	2
France, ...	139	40	72	21
Germany, ...	54	21	30	12
Italy, ...	33	13	15	9
Russia, ...	65	12	27	3
Spain, ...	34	2	28	3

* Does not include torpedo gunboats, composite gunboats, or older vessels.

The vessels are here classified to include, first, all vessels fitted for blockade duty, and comprise armored ships of all classes, not coast-defense vessels, cruisers, and gunboats of more than 800 tons; second, all vessels capable of attacking fortified positions and bombarding, and comprise all armored vessels mounting rifled guns of 10-inch or larger caliber, not coast-defense vessels; third, all vessels suited for marauding and attacking less strongly fortified places, or bombarding unfortified places near enough deep water to be within range of their guns, and include all cruisers and larger gunboats, not including armored ships; fourth, all vessels adapted to acting singly along the coast of an enemy for the purpose of destroying commerce, shelling unprotected towns, carrying despatches, etc., and include all fast cruisers of 15 knots and upwards. Torpedo-boats have no place in this table, because I intend to show that they are not adapted for attack upon a distant coast, and will not be used for that purpose except, possibly, at three places upon our coast; and even at these they will be of little use if proper provision is made against them.

Before proceeding farther with our subject, it becomes necessary to fix some limits to the responsibility of the navy in defending the coast, and to decide what part of the duty shall be performed by the navy and what part by the army. We are met at the very outset by the fact that there exists a considerable difference of opinion upon this question between the army and navy. A consideration of these differences and the reasons for them, pro and con, would require much time, and probably lead to no decisive result. The scheme of naval defense that is here submitted should be practicable and adapted to the situation as it exists. We shall, therefore, assume the present division of duty between the army and navy as the proper one, reserving a few suggestions upon the matter for another time.

It is evident, then, that in providing for a proper naval defense of our coast, we must assume that that portion of the defenses which belongs to the army has been provided. If we were required to provide a naval defense that would effectually supplement the present land defenses, it would require a navy enormously greater than would be necessary with properly constructed land defenses. It is understood that no such naval establishment is contemplated—only what would be necessary to secure our coast against molestation after everything had been accomplished by forts, submarine mines, etc., that properly belong to the land defenses. These should be able to resist unaided, though they may not completely protect the city, the attack of any naval force that could be brought against them, whether by one nation or a combination of them. If these defenses can be placed at such a distance in advance of the objects to be defended as to render it impossible for any attacking fleet to reach these objects with its heaviest guns, and the channel-way is so obstructed by mines or other means as to make it impracticable to pass the forts, then the land defenses become a sufficient and complete protection. If the city to be defended is so near deep water as to make this arrangement of the fortifications impossible, or if a fleet can bombard the city without passing the forts, or if the channel-way to be guarded is too broad to be protected by gun-fire, or the current too swift or water too deep to permit the use of mines, or the nature of the shore, as at the mouth of the Mississippi, does not permit the construction of forts, then in all such cases the defense must be made, in whole or in part, by floating structures. The characteristics of these floating defenses must depend upon the position to be defended. In other words, they must, in a measure at least, be adapted, like the fortifications, to the particular place to be defended, and consequently must form a part of the defenses of the place, and not a part of the sea-navy detailed for this duty, though, of course, belonging to the navy.

Before going into particulars, it will be well to classify the means for naval defense as far as possible, and for convenience they may be divided into *torpedo-boats*, *gunboats*, *rams*, and *floating batteries* or *coast-defense* vessels.

The characteristics of torpedo-boats are so well known and conform so nearly to one standard regarding speed and handiness, that it is unnecessary to do more in this place than say that an attempt will be made to show that they will form a most important part of the defenses of the coast. Their use at sea in a naval engagement is of very doubtful utility; but where they can act from a shore base, only making excursions of short duration, when they can select their opportunities, starting with fresh crews and every detail in perfect condition, they become weapons of great destructive power, and produce a moral effect resulting in a great advantage to the defense. For this purpose of defense they should be as small as possible consistent with the necessary speed and ability to carry the required weapons. The utility of torpedo-boats, in the estimation of naval men, has fluctuated in a most remarkable manner during the past few years. At one time they were looked upon as threatening extinction to ironclads, and as a sure and sufficient means of defending a coast; swift, invisible, and striking a fatal blow, all nations made haste to provide themselves with great numbers of these little craft. Had the capacity to build them been greater, the number in existence to-day would be much greater than it is, owing to the desire to possess them. Trials at sea demonstrated, however, that they had not the sea-keeping qualities at first inferred from the long voyages which those first constructed had made. The many breakdowns under normal conditions at sea, added to the protection against torpedo attacks furnished by steel nets, had the effect of greatly reducing the number of their friends. To overcome these objections and make these little vessels seaworthy, they were increased in size until they have, in a great degree, lost one of their most important characteristics, viz., invisibility.

It is only under exceptionally favorable conditions that torpedo-boats should attack during the daytime. The Minn river episode cannot be taken as a fair indication of what would happen in a similar fight between European nations. But, at night, the moral effect upon a ship's company would go far to destroy the efficiency of their defense when they realized that they were attacked by a number of torpedo-boats. On the other hand, the immunity furnished by darkness to those in the torpedo-boat infuses them with courage and confidence; all their faculties are under command and they are capable of their best efforts. Recently a more moderate and reasonable estimate of the abilities of these boats has prevailed, and they have, somewhat, been restored to favor. Their legitimate field of operations is that above indicated, as coast defenders. They will not be used to any considerable extent by a naval force acting against the defenses of a coast.

The distinctive features of a coast-defense vessel, as compared with a sea-going vessel, are that the former should possess the maximum powers of offense and defense, with the least practicable draught and displacement. Great speed and the ability to keep the sea for any considerable time are relinquished in the coast-defense vessel, in order to secure the important qualities of light draught and handiness that belong to a small vessel. The modern sea-going ship, on the other hand, should possess high speed and great endurance, and with these must be combined offensive and defensive powers according to the duties expected of the vessel. It is, therefore, much easier to combine in a single vessel the qualities required in a coast-defense vessel, than it is to secure the necessary qualities in a sea-going ship. Indeed, so impracticable is it to combine in one vessel high offensive and defensive powers together with great speed and endurance, which are only the main requisites in a sea-going ship, that it is no longer attempted; but certain qualities are sacrificed to secure some other in the greatest degree of excellence, and for special purposes, as when defensive power is sacrificed to speed or endurance, or when the latter is given up to secure offensive power.

Coast-defense vessels should have an advantage over any vessel carrying the same guns that may be sent against them. Such an advantage would be secured were they of lighter draught, enabling them to work over shoal water where the enemy could not follow. In such cases they would be secure against ramming, and probably against Whitehead torpedoes. Such an advantage would also be possessed had they great manœuvring power, enabling them to take positions of advantage; and this would be secured by having smaller vessels than those of the enemy, and fitted with twin screws. The coast-defense vessel should then mount guns equal or superior to any probable enemy; she should have protective armor of greater thickness, while she should be, at the same time, a smaller vessel and of lighter draught. The architectural problems involved in the construction of such vessels have not been as carefully studied as in the case of deep-draught vessels. The model experiments that have been made in Europe, to determine the best form of vessel, have not included the question of large displacement on light draught. Other nations have not the interest in this problem that we have, and our government should provide for its careful study.

To the efficient defense of a coast, it is important to be able to act offensively when opportunity offers, or when an advantage would be thereby gained. A blow struck at such a moment may be decisive, while to be powerless to follow up the effect of a repulse by the fortifications would permit the enemy to recuperate and renew the attack, or at least to withdraw when they might have been destroyed. If, during an attack, one or more of the enemy's ships take the ground, or otherwise become temporarily disabled, a prompt attack by coast-defense vessels might completely disable or even destroy them. An enemy's fleet will attack a fortified position with confidence if they know that they have only to withdraw in case they are worsted, and that there will be no danger of further injury beyond the range of the forts. A hostile fleet arriving off any one of our large ports defended by forts and mines, could deliberately plan and try one method of attack after another. They could concentrate their efforts upon one point, or divide the fleet, and attack several points at the same time, and they could make the attack either during the day or night. If, however, the stationary defenses are supplemented by coast-defense vessels, rams, and torpedo-boats, the enemy must be much more circumspect, and his position becomes critical if, from stress of weather or other cause, any of the fleet loses the support of the remainder. A night attack becomes hazardous in the extreme. He must withdraw the main part of the fleet far from the coast during the night, to prevent surprise from torpedo-boats. He must at all times have assembled a force superior to that which may at any moment emerge from the port to attack him.

It therefore appears to be desirable to supplement the land defenses by such floating defenses as will make the approach of an enemy more hazardous, and restrict his demonstrations to the narrowest limit possible. While such floating defenses may not materially augment the statical defenses of the place, their presence compels the enemy to make more extensive preparations for a given attack, requires a larger force and greatly increased caution. In this indirect way the floating defenses add largely to the resisting power of a given locality. This may be considered the passive influence of floating defenses; but they may play, also, an important active part, under circumstances that are adapted to their peculiar functions, and that are sure to arise in all naval attacks. Coast-defense vessels may even constitute the main defense of a port whose peculiar position does not permit its being defended by forts.

The duties here outlined for coast-defense vessels may be less efficiently performed by the regular naval force, but the legitimate field of action of such a force is upon the high seas, in protecting our commerce, in destroying the commerce of the enemy, in making attacks upon undefended and important portions of his coast (thus forcing him to maintain a fleet at home), or in meeting and destroying his fleet. If the navy proper is held for coast-defense, these other important duties must be largely neglected, and some of the most efficient means of bringing the enemy to terms be disregarded. A naval force that is adapted to the wide range of its duties at sea is not well adapted to the work of defending a coast. Vessels capable of carrying and fighting heavy guns at sea, under all conditions of weather, must have great displacement, drawing too much water for service in the shoal waters of our harbors. Such vessels would have no advantage over vessels of the enemy mounting similar batteries, whereas vessels can be built that will have decided advantages under the same circumstances. The small depth of water of our Atlantic ports, if rightly taken advantage of, may prove one of our strongest means of defense. Great ironclads carrying the heaviest guns, and possessing sufficient endurance to be sent across the ocean, must necessarily draw so much water that they could either not enter many of our ports, or could do so only with the greatest caution; while vessels intended only for coast defense could be built, carrying the heaviest guns with ample protection, which should be able to manœuvre in our harbors and easily destroy a vessel limited in its manœuvring power by its great draught of water. With us, this argument has peculiar force, and too much stress cannot be laid upon it. We should not hesitate to avail ourselves of a means of defense so admirably adapted to our peculiar coast.

Floating defenses should be employed in the following cases:

1. Where the proximity to deep water of the place to be defended renders it impossible to make a proper defense by batteries on shore.

2. Where the great width of the approaches to the place to be defended renders it impracticable to reach all points of such approach with an efficient fire from guns on shore.

3. In places where from the nature of the ground, as at the mouth of the Mississippi river, it is impracticable to mount heavy guns in forts.

These three cases may be considered as being decided by conditions imposed by nature. In the first of the three cases cited, where coast-defense vessels should be employed, the application of the rule will depend upon the range of guns mounted on board ship. For it is evident that in order properly to defend a city, the vessels of an enemy should not be permitted to approach it within the extreme range of his guns without coming within destructive range of the guns forming the defense. A city forms a large target, and when it can be reached by a fire of heavy shells its destruction is certain. A vessel, on the other hand, forms a small target; and when it is heavily armored and in rapid motion, it can be injured only at short range. It therefore becomes necessary at the outset to decide upon what may be considered the extreme range of guns mounted on board ship. The range of the heaviest high-power guns has been estimated probably with considerable accuracy, and may safely be taken as 10 miles. As this extreme range is secured only at considerable elevation, thus making the energy of the recoil in a vertical direction very great, ships are probably not constructed now to withstand such great strains, and consequently could not avail themselves of the extreme range of their guns. Yet there is no reason why vessels should not be so constructed, while a wise precaution would lead us to take it for granted, and even anticipate a large increase in the range of the guns of the future. Assuming that an armored vessel cannot maintain her position for any considerable time within 2 miles of the heaviest guns mounted in forts, it would appear that a city would be, theoretically, perfectly defended if the defenses were 8 miles in advance of the city. The attacking vessel would then be compelled to remain at a distance of 10 miles.

Applying these considerations to the case of Boston, it will be seen that if heavy guns are mounted on the outer islands at the entrance and at the east point of Nahant, there would still remain a small space in Broad Sound, within 6¼ miles of Boston State House, which would be more than 2 miles from any guns mounted on shore, yet only a little more than 2 miles; and the margin being so small, in this case the city might be considered as well defended if proper defenses were erected on shore. On the other hand, in foggy weather to which that part of the coast is subject, the enemy could enter Broad Sound to a point within 6 miles of Boston State House. A fog would not prevent the approach of the enemy, nor would it materially interfere with the destructiveness of his fire.

The functions of the gunboat in coast defense are similar to those of the larger vessel; the difference in size entailing upon the gunboat light armor, or no armor at all, and lighter guns. The gunboat would, therefore, be adapted to the defense of less important positions, or positions where only light guns could be brought to the attack. Being small, and carrying but one heavy gun, she would depend upon her small size rather than armor to escape injury from the enemy's shot. Like the coast-defense vessel, every consideration of coal-endurance and sail-power must be sacrificed to weight of gun. Only moderate speed but great handiness are essential. A vessel to mount one ten-inch armor-piercing gun can be constructed upon a displacement of 300 tons and a draught of 7 feet, with a speed of ten knots and an endurance of about 1000 miles at 8 knots, to have two screws and protection against machine guns.

The office of the ram in coast defense will be similar to the torpedo-boat; acting on the offensive by making excursions against the enemy at night and in thick weather; in attacking a vessel that has become disabled by gun-fire or a torpedo, or that has grounded or become deprived of the support of her companions from any cause, as well as acting in conjunction with the other vessels in a general attack. The essential characteristics of a ram for coast defense are sufficient weight to accomplish the destruction of any vessel by ramming, which would probably result from 3700 tons at a speed of 15 knots, which would give a striking energy of 27,750 foot-tons. The speed should be as great as possible, in order that her weapon may be effective. She should have manœuvring power and speed sufficient to enable her to ram any armored ship. As before stated, she will be required to act outside, where her greatest speed will be required, where other vessels will also be able to manœuvre at high speed. She should have the maximum protection that the other conditions will permit. These characteristics will exclude any heavy battery. Indeed, the vessel herself is the projectile, and to complicate its use with that of guns would serve only to detract from its efficiency. A gun could be used only by chance; a ram would be expected to meet the most powerful ships built, and against their armament her single heavy gun, if she were provided with one, would count for very little.

The ram should, therefore, have a draught not exceeding 15 feet, a displacement not exceeding 3700 tons, a speed of 20 knots, with twin screws. She should be constructed in a manner to endure safely the shock of ramming, and be well protected by armor, especially from the gun-fire of the vessel she may be attacking. Light draught is necessary for the same reason that it is necessary in the case of other harbor-defense vessels, that she may manœuvre in shoaler water than the enemy. The high speed is necessary in order that she may use her ram. Although such speed would not be necessary in a harbor, because an enemy would not venture to manœuvre at full speed, yet it would certainly be required when attacking the enemy in open water. The least displacement possible with the necessary weight is also required, in order that the vessel may turn quickly. Coal endurance may be reduced to a minimum.

It should be here remarked that the vessels so far suggested are intended only to complete the defense of our ports, in conjunction with the land defenses, against a naval attack; and also to prevent a close blockade by a naval force inferior to the vessels that may be assembled for the defense of the port. This much they would be prepared to do without reference to the cruising vessels of the navy. It should also be explained that no reference has been made to either the dynamite gun or submarine torpedo-boat as coast defenders, because it is believed that the pneumatic gun is not adapted to such service.

The writer is aware that in this he differs from the opinion held by many army officers upon this general subject of mortar fire. While the pneumatic gun admits of greater accuracy of fire than a mortar, because of the precision with which the pressure can be controlled, yet it is essentially a mortar, and the inherent defects are the same in both, when used against a moving target, when the target is not constrained to move over any particular area, or at any particular speed, or in any particular direction. A heavy mortar fire that can be directed upon a particular area, as a point in the channel-way over which a hostile fleet must pass, would, certainly, furnish a most effective means of defense; and the pneumatic gun, under the same circumstances within its range, would give a better defense than mortars if this range does not fall within the mine field of the defense. As a naval weapon it is soon to be tested in the dynamite cruiser, and if, under the conditions of practice afloat, it can accomplish its object better than the auto-mobile torpedo, then it should be adopted without reference to the possibility that it may be superseded by a powder gun for projecting the torpedo. Even in the present highly developed condition of the weapon, it is not practicable to assign it a place and specific duty in the defense of the coast. It promises well; but good promises cannot be made available in so serious a matter as the defense of our country. We must, therefore, wait until further trials determine its capabilities as a naval weapon.

The writer considers that the submarine torpedo-boat should be placed in the same category as an untried weapon. It carries the characteristic of invisibility to the utmost limit, but I think it has thereby greatly limited its usefulness as a rival to the surface torpedo-boat. A submerged torpedo-boat could not operate against a ship under way; there is no means by which the position of the enemy could be determined after the boat is submerged. It is not an answer to say that the boat need not be *entirely* submerged when attacking a moving ship. If it is not necessary that she should be so submerged, then she should not be a submarine boat; and it is possible that such a degree of invisibility as is possessed by a so-called submarine boat when her conning tower is above water should be given to all our torpedo-boats. But it is evident that, in dispensing with the appliances necessary to secure complete submergence, the boat becomes less complicated and expensive. In the submarine boat, a lingering connection with the surface might be had by means of a mirror throwing the image of the enemy down a tube fitted water-tight upon the surface of the glass dome. This might be destroyed without detracting from the safety of the boat. Certainly there are other fields for the use of a submarine boat in coast defense than in attacking the enemy under way. In the attack of a ship at anchor at night she might pass beneath the protecting torpedo-net and attach her torpedo to the bottom of the ship. The boat would be more serviceable to the attack in exploring mine-fields, placing counter-mines, etc., etc. As a coast-defense weapon, I think, for the present, its place must remain unsettled.

Whether gunboats or larger vessels will be required in any particular case will depend upon circumstances, and each case must be considered by itself. As before stated, the local conditions must decide this question as well as many others. I may here refer to the principal conditions, one or more of which will exist in each case, and leave the special application until we come to consider in detail the points to be defended. First, then, is the importance, either from a military or commercial point of view, of the place to be defended. Remembering that we now refer only to such places as are found to require naval defenses, it is readily seen that where the temptation to attack is not great, the defenses may be moderate. The wealth, commerce, and dock-yard of a great city like New York would call forth the greatest efforts of an enemy. Ships might be lost, many lives sacrificed, and much time consumed in the capture or destruction of a city like New York, and the result to the enemy or the loss to us would be sufficient return to the enemy. As an example of another kind of temptation to attack, we may cite the city of Portland, Maine. Should we ever become involved in war with England, the possession of this city would be of the first importance to that country, from its strategical position. It is the terminus of the Grand Trunk Line of Canada, over which is most conveniently carried all the winter traffic of Canada. The harbor of Portland is excellent and never obstructed by ice, and this is not the case with any other harbor along that coast. Portland would, therefore, seem to be a necessity to any campaign carried on from Canada.

The second local condition to assist in deciding the character of the naval defense is the depth of water from which the position must be attacked, and this condition acts to decide the character of the naval defense in two ways: (*a*) by limiting the size of the vessels that can engage in the attack; and (*b*) by limiting the draught of vessels that can be used in the defense. The following table shows the number of vessels belonging to each country named that can enter the principal ports of the United States, the vessels being divided into two classes—the first comprising all vessels mounting modern guns capable of piercing from 12 to 20 inches iron, and the second, vessels mounting guns capable of piercing more than 20 inches of iron. From this it is seen that the comparatively light draught of water that can be carried into most of our principal ports furnishes a bar to the entrance of the larger armor-clads of Europe.

ATLANTIC COAST.

The conformation of our Atlantic coast is such as to form natural divisions or *sections*, as I have chosen to call them, which may be defended separately. In the scheme of coast defense that I have to propose, the defense of each section is made independent, and comprehends the defense of all points within the section. The vessels of every description provided for each section would constitute a separate command, in order to secure unity of action. In certain cases and under certain conditions, the forces of two or more sections would be combined. The command of all the coast defenses from Eastport to Galveston would be under the control of a single officer, who would be stationed at some central point on shore, preferably New York. His duties would consist in centralizing all information regarding the enemy and his movements. He should be in direct telegraphic communication with the station of each commander of a section. He would receive reports from them, of everything happening in their section, and in turn transmit information to them of the approach and strength of the enemy. The main duty of the office would be to decide when the naval forces of two or more sections should be combined. Beyond this decision, he would not interfere with the operations of each commander of a section while he was dealing with the enemy. When the defenses of two or more sections were combined, they would be under the command of the officer in charge of the section in which they were acting.

NUMBER OF VESSELS BELONGING TO ENGLAND, FRANCE, GERMANY, ITALY, AND RUSSIA.

(Showing number of guns carried, divided into two classes: 1. Those capable of piercing 12″ to 20″ wrought iron; 2. those capable of piercing 20″ to 33″ wrought iron at the muzzle.)

Ports.	Draught of ships that can enter.	ENGLAND.			FRANCE.			ITALY.			RUSSIA.			GERMANY.		
		Number of ships.	Number of guns that will penetrate 12″ to 20″.	Number of guns that will penetrate 20″ to 33″.	Number of ships.	Number of guns that will penetrate 12″ to 20″.	Number of guns that will penetrate 20″ to 33″.	Number of ships.	Number of guns that will penetrate 12″ to 20″.	Number of guns that will penetrate 20″ to 33″.	Number of ships.	Number of guns that will penetrate 12″ to 20″.	Number of guns that will penetrate 20″ to 33″.	Number of ships.	Number of guns that will penetrate 12″ to 20″.	Number of guns that will penetrate 20″ to 33″.
Portland Narragansett Bay Hampton Roads	Any draught do. do.	97	589	...	51	235	...	18	116	...	24	56	...	22	65	...
		15	...	50	16	...	44	9	...	36	0	...	0	0	...	0
Boston New York New Orleans	Less than 26′ do. do.	72	348	...	28	82	...	9	28	...	24	56	...	22	65	...
		2	...	4	7	...	18	0	...	0	0	...	0	0	...	0
Baltimore	Less than 25′	69	316	...	26	74	...	7	14	..	19	30	...	20	49	...
		2	...	4	7	...	18	0	...	0	0	...	0	0	...	0
Philadelphia Norfolk	Less than 23′ do.	61	259	...	16	32	...	7	14	...	18	26	...	18	41	...
		0	...	0	1	...	2	0	...	0	0	...	0	0	...	0
Pensacola	Less than 21′	51	165	...	11	14	...	7	14	...	18	26	...	18	41	...
		0	...	0	0	...	0	0	...	0	0	...	0	0	...	0
Washington	Less than 20′	43	77	...	11	14	...	7	14	...	18	26	...	18	41	...
		0	...	0	0	...	0	0	...	0	0	...	0	0	...	0

The commander of each section would also be stationed on shore at some central point in his section, whence he would be in direct telegraphic communication with the commander-in-chief, and with every town and lookout station within his section. His duties would be to transmit to the vessels of his command all information regarding the movements and strength of the enemy, and to order them where to meet the enemy on his approach, and to give general orders as to the mode of attack or defense. The general rules regarding naval command afloat would hold from the moment telegraphic communication ceased between the commander of a section and the senior officer in command of the vessels. Communication should be renewed at short intervals, however, by means of the torpedo-boats, for the sole purpose of obtaining information.

The first section in this plan is the coast from Eastport to Cape Ann. This curve of the coast presents a case that is not to be found elsewhere. The many and deep harbors that indent the coast permit an enemy's vessel, of any draught, to approach the numerous and thriving towns to any desired distance. The great depth of water at the entrance to Penobscot bay, and the considerable rise and fall of the tide on the whole coast, together with the swift currents, make the use of submarine mines difficult, if not impossible. The great length and breadth of Penobscot bay renders it impossible to defend it by fortifications; while at least five thrifty towns and cities situated on its borders can be approached by deep-draught ships.

It is therefore proposed to make the defenses of this section from Eastport to Portsmouth mainly a floating defense, and to treat that distance of about 200 miles as a unit; or in other words, adapt the whole defending force to act at any point within this distance, and at the same time make it sufficient to defend all points on the line at once.

It is to be observed that the natural conditions existing throughout this section are very similar; there is sufficient depth of water for the largest vessels to approach any of the towns, and their proximity to either a broad bay or the open sea renders defense from land impracticable. The inducements to attack are about equal at the different points to be defended, except, perhaps, in the cases of Portland and Portsmouth already referred to. If some were defended and others left without protection, the enemy would select the latter for any purpose for which any of them might be required. On the other hand, there are no large cities within these limits, and they would not, therefore, present a strong temptation to plunder. In case of a war with England, the capture of these towns by the fleet would secure the flank of an advancing army. This last contingency, as before stated, is probably a remote one. It is, therefore, thought that the defense of this coast can be secured by the following vessels :*

No. of Vessels.	Type.	Guns. 12-inch.	Guns. 10-inch.	Cost.
3	2d	6	6	$9,000,000
2	Rams	...	...	2,000,000
30	Torpedo-boats	...	...	3,000,000
		Total........	....	$14,000,000

In time of war the torpedo-boats would be distributed to the principal ports in groups of not less than five (5), which should always be prepared to act together. The large vessels would be divided into two or more divisions, most advantageously stationed at Portsmouth, Portland, and the Penobscot river. The officer in command of the section would be stationed at Portsmouth, and would constantly be in telegraphic communication with each division.

Massachusetts Bay, which measures but forty (40) miles from Cape Cod to Cape Ann, constitutes the second section. It may be defended by the following :

No. of Vessels.	Type.	Guns. 14-inch.	Guns. 10-inch.	Cost.
2	1st	4	4	$7,000,000
2	Rams	...	...	2,000,000
10	Torpedo-boats	..	...	1,000,000
		Total......	......	$10,000,000

Within this bay are situated the towns of Gloucester, Salem, Marblehead, Lynn, Nahant, Plymouth, and Provincetown. These, together with the city of Boston and the numerous towns that constitute its suburbs, can be reached by guns mounted on board ship from deep water and without coming within too destructive range of any possible fortifications.

None of these smaller sea-ports are now protected by any fortifications, and it would be impracticable to do so. Broad Sound is the only position from which Boston can be bombarded without coming within close range of fortifications that might be placed upon the islands that form the limits of the outer harbor. As before stated, a vessel can take a position in this sound two miles from any possible fortification and be within six (6) miles of Boston, East and South Boston, and Charlestown. Fortifications placed at Nahant, Grover Cliff, and Winthrop Head would have such a vessel at a range of about two miles, and it might be assumed that a vessel, or a number of them, would not take such a position for bombardment in daylight if suitable fortifications were placed as above indicated. It may also be granted that during a clear night the search-light would be sufficiently powerful to reveal the position of a vessel at that distance with sufficient distinctness to enable the guns of the fortifications to be pointed. If the night were misty, the electric light would not reveal the position of the enemy, and, in one of the fogs so frequent on that coast, the fortifications would be powerless to discover the position of the enemy; for the sound of his guns would be no guide.

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* See Appendix for general description of these vessels.

Now there would not be the least difficulty to the commander of a vessel, even in a thick fog, in placing his ship in the desired position in Broad Sound, or in pointing his guns to drop the shell within the limits of the city of Boston. The angle subtended by the city at the distance of six miles in Broad Sound is about 25°, and the rectangle of fall within which the shell would produce damage would be two miles square. When the range corresponding to different elevations is known, it would be perfectly practicable to point a gun by compass bearing with all required accuracy to hit a target having an area of four square miles. Indeed it is probable that the pointing would be done in much the same way in daylight and clear weather at such a long range. It is, therefore, evident that the cities and towns situated on this bay cannot be defended without the assistance of a naval force. Certainly the whole bay could be blockaded by comparatively few vessels if there were none to oppose them. The naval force here prescribed for the defense of this section would certainly deter a much superior enemy from approaching in a fog or darkness. The better local knowledge possessed by the defense, and the better means at their command for determining the approach of the enemy, would change to a state of great uncertainty the feeling of confidence and security that the enemy would possess if they knew they had only the fire of the forts to encounter. It is doubtful if any commander would venture to retain even a much superior force within the limits of the bay, when he knew he was liable to attack from four such vessels as are here recommended.

It must be remembered that the defense has the advantage, under such circumstances, of many watchful eyes along the whole coast, and of the telegraph to quickly inform the defenders, of the position and movements of the enemy. This great advantage of rapid communication is one of the main reasons for proposing this method of defense. The early notice that the defense may receive of the intentions of the enemy, and the promptness with which the defense-vessels may assemble at any threatened point, make it practicable to offer immediate resistance at all points. An enemy entering this bay to approach any of these towns must pass within less than twenty miles of the land. Look-out stations at Cape Ann and Cape Cod, together with a few look-out torpedo-boats, would (in fair weather) be able to see an approaching enemy, and, by telegraph, warn the commander of the section at Boston. The enemy having entered the bay—which he would not dare to do with a force inferior to the defense—a strict watch would be kept upon his movements, and the defense would be prepared to strike a blow at the first opportunity. The one precaution that would have to be observed constantly in this case would be not to permit a superior enemy to get between the defending vessels and the fortifications of Boston, which must be considered as the rallying point when pressed by a superior force. With a fair chance of success, the section commander should give battle at any time; while against a decidedly superior force he must employ every means to prevent the enemy from approaching the coast to bombard it. A threatening attitude at all times, with vigorous attacks with the rams and torpedo-boats at night and in thick weather, would rapidly reduce the enemy's coal supply, and render his position dangerous.

It is not intended to lay down rules of action to guide the use of the proposed naval defense, further than to point out that it would be adequate to meet the demands made upon it. The mere presence of such coast defenders at once and always, fixes the limit to the naval force that will venture to attack the section defended. Against all inferior forces the section of the coast is secure.

The next and third *section* comprehends Buzzard's Bay, Narragansett Bay, and Long Island Sound. A glance at the chart shows that all the places to be defended along this stretch of coast from Cape Cod to New York lie within the waters above named. It is also seen that these two bays and Long Island Sound open upon a common and very limited area. From the Elizabeth Islands, which form the southern shore of Buzzard's Bay, to Montauk Point, is only fifty miles.

Any vessel entering either of these large sheets of water must pass between these points. It is, therefore, seen how readily this section lends itself to a naval defense, that, acting within a limited area, may protect many large cities and deprive the enemy of any harbor of refuge. In this connection may be seen the great advantage that would be secured to a naval defense of the coast from a canal cut through from Buzzard's Bay to Massachusetts Bay. Such a canal would permit the speedy combination of the defenses of these two sections, and permit the concentration of a double force upon an enemy appearing at either point. The distance between the headquarters for the defense of the two sections would be less than 100 miles, while the enemy passing from one point to the other would have to traverse a distance of 233 miles, thus enabling the two squadrons of the defense to combine in less than eight hours. With suitable look-out vessels to watch the movements of the enemy, he might easily be confronted by the united defense of the two sections, at whichever point he might appear.

I think the strategical importance of such a canal would warrant the expense of its construction, while its commercial value would be very great, forming a practically inland route between New York and Boston. Buzzard's Bay cannot be defended by forts, as the distance across the mouth of the bay is six miles. New Bedford cannot be approached much nearer than six miles, if the buoys were removed. Protecting forts can be placed on either side of the harbor entrance, at a distance from the city of four miles on one side and five miles on the other. The city would not, therefore, offer a very great temptation to bombardment, and would be entirely secure with a moderate naval defense to prevent blockade. Narragansett Bay can be closed by forts, if submarine mines can be used at such a depth as would be here required. The city of Newport, however, can be reached at moderate range from the open sea. Only a naval defense can make it or the naval station secure against bombardment. Long Island Sound can be protected only by ships. The Race is about four and a quarter miles wide, and this would be the distance apart of any fortifications which might be placed upon Gull and Fisher's islands. The other passage into the sound may be closed by gun-fire alone, as it is narrow. An enemy would use the Race, no matter how strongly protected by forts.

A paper read before the U. S. Military Institution criticises the "Board on Fortifications and other Defenses," for not defending this passage, and thus protecting all points within the sound, including the eastern entrance to New York itself. The Board was of opinion that an enemy could not be stopped at the Race by fortifications, and as that Board was organized to make practical recommendations, I think it wisely placed the defenses where they were confident the enemy could be stopped. The recommendations of the Board did not present the beautiful simplicity of the plan in the paper above referred to, in which 20-inch guns are advocated for each side of the Race.

It should be remembered that submarine mines could not be used here, thus leaving the passage free to a vessel to pass at full speed. A vessel passing in with the current need not be under fire from fortifications on Gull and Fisher's islands more than half an hour. On a dark night, or in foggy weather, which so often prevails in this locality, vessels might pass through the Race without being discovered from shore, even with the best use of search-lights. Indeed, I am of opinion that the use of search-lights under such conditions would be of greater advantage to the enemy's ships than to the defense; because they would clearly mark the limits of the passage, and enable an officer to dash through with entire confidence, which he would lack if all lights were extinguished. The naval members of the Board above referred to, recognizing the overwhelming importance of making Long Island Sound secure against intrusion, recommended—as will be seen by reference to the report—four vessels mounting four 14-inch, four 12-inch, and eight 10-inch guns, besides torpedo-boats.

After a careful consideration of the case, and combining the defense of this sound with the necessary naval protection for Buzzard's and Narragansett bays, I have concluded to add to the defense above recommended two rams, making the defense of this section consist of the following:

No. of Vessels.	Type.	Guns. 14-inch.	12-inch.	10-inch.	Cost.
2	1st	4	...	4	$7,000,000
2	2d	...	4	4	6,000,000
2	Rams	...	...	...	2,000,000
20	Torpedo-boats	...	...	...	2,000,000
					$17,000,000

It must be understood that the naval defense here recommended is not to protect completely every point within the sound, and to perform the office of the guns that it has been proposed to mount at the entrance to the sound or at Throgg's Neck, for the defense of New York. A wise precaution would require fortifications at these and other points, to make security doubly sure. The protection furnished to the shores and commerce of Long Island by the above-named vessels would be greater than could be given in any other practicable way. Even a large armor-clad fleet would not venture into the sound in the presence of such a defense.

Section 4, in this plan, would be the harbor of New York and adjoining waters. The land defenses proposed by the "Board on Fortifications and other Defenses" would be sufficient to protect New York and, probably, Brooklyn as well, except in weather favorable to the attack, when the enemy might be able to approach Coney Island near enough to shell Brooklyn and even the lower part of New York. But such defenses are not all that is required; it must not be possible for an enemy to blockade the port and cut off the commerce of this city.

The harbor of New York may be said to be the throat of the nation, through which it breathes, and to permit an enemy to close it would be to submit to strangulation. The great importance of securing our coast against actual invasion or bombardment has prevented us from a closer examination of what would result if our principal ports were only blockaded. Two-thirds of the revenues that support the government, or more than $200,000,000 annually, are derived from duties on imports, two-thirds of which enter at the port of New York. Not only would the revenue be cut off for the time being, if the port were blockaded, but the vast system of internal transportation, centering in this city, by which these imports, amounting to 500 millions of dollars annually, are distributed over the whole country, would be without this occupation; while the same system of transportation that now annually collects from a vast area of country more than three hundred millions of dollars' worth of merchandise and sends it through the port of New York to every part of the globe, would lose this occupation also.* These causes re-acting in a thousand ways along all the internal lines of trade would produce widespread loss and confusion. Nor can these great streams of commerce be readily changed to other seaports, granting for a moment that our enemy leaves us such a resource. To effect such a change would only be easier than to change the course of the Mississippi to the Atlantic. All the great thoroughfares of traffic are adjusted to a condition of things that now exists and that has been the evolution of many years, and this condition cannot be changed without giving the rudest shock to every industry in the land. It is not the city alone that would suffer, but every farmer and manufacturer would find the foreign market for his productions cut off. Nor would it necessarily be only a temporary stoppage of trade that would be resumed at the close of the war; for it must be remembered that this country, which now exports nearly one hundred millions of dollars' worth of breadstuffs annually, holds the market by only a small margin, due to the slightly lower freight rates from the United States to Europe than those which now prevail between India and Europe. That country is capable of producing vast quantities of wheat, and should the supply from this country be cut off at seeding time, it would stimulate the production in that country and turn the tide of trade in that direction.

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*No account is here taken of the coasting trade, which would equally suffer from blockade.

We know to our sorrow that a trade once lost is difficult to regain. Before the war, American shipping carried 75 per cent of our foreign trade, then amounting to 700 millions annually; during the past year, American ships carried 14 per cent of our foreign trade, now amounting to $1,400,000,000; and a little calculation will show that this loss in percentage in our carrying trade is not only because our shipping has not kept pace with the enormous increase in the trade, but also because we are not now carrying much more than one-third as much as we did before the war, notwithstanding the trade itself has more than doubled. Let us take warning from this experience and not permit other branches of traffic to slip from us, possibly never to be recovered, or only after the sharpest competition, which means small profits and poverty. I am convinced that if the port of New York were blockaded for even a few months, the loss that would result to the nation might be as great as would be produced in the city by a bombardment. It is, therefore, very important to provide against the possibility of such a blockade. This can be done only by an adequate naval defense, in addition to the fortifications. The defense proposed is the following:

No. of Vessels.	Type.	Guns.		Cost.
		14-inch.	10-inch.	
3	1st	6	6	$10,500,000
3	Rams	...	...	3,000,000
20	Torpedo-boats	...	...	2,000,000

If any doubt is entertained as to the ability of such a defense to prevent the blockade of New York, it must be remembered that the vessels defending Section 3 can readily come to its assistance by way of East River, and we should have seven ships mounting fourteen 10-inch, four 12-inch, and ten 14-inch guns, five powerful rams, and forty torpedo-boats; and I venture to say that such a force would be sufficient to drive off any blockading fleet. It might not be prudent to draw off all the naval defenses of the third section to assist in the defense of the fourth, but a careful watch and the use of the telegraph would enable those in authority to decide upon the disposition of the vessels without much hesitation. The advantage given to the defense by telegraphic communication was well exemplified during the English manœuvres last summer, though it does not appear to have been taken advantage of to the fullest extent, owing to the fact that the blockade was abandoned by the blockaders in order to defend their own coast as soon as a few of the blockaded vessels had escaped. Had the blockade been continued, the blockaded vessels could have escaped, and by combining their forces at a pre-arranged point, have been able to fall upon one of the blockading fleets with a superior force.

Another manifest advantage to the defense is the proximity of supplies of all kinds, while the enemy is far removed from his base, and, if the defense is active, the enemy must consume his coal rapidly and detach his ships in turn for a new supply. If repairs are needed, the defense has its dockyards at hand, while the enemy may have to cross the ocean to secure the needed facilities.

The 5th Section is formed by Delaware Bay. The important places situated upon the Delaware river can be completely protected by fortifications, so that a naval defense is needed only to prevent the enemy from taking possession of the lower bay and closing the port by a blockade. To accomplish this, the following force is deemed sufficient:

No. of Vessels.	Type.	Guns. 12-inch.	Guns. 10-inch.	Cost.
1	2d	2	2	$3,000,000
1	Ram	...	...	1,000,000
10	Torpedo-boats	...	...	1,000,000
				$5,000,000

The 6th Section is formed by Chesapeake Bay and adjacent waters to the southward. This sheet of water is, from its great extent and southerly position, as well as because of its extensive commerce, one of the most important places upon our coast. The large amount of through traffic upon this bay, which is a link in the interior waterway of our coast, as well as the extensive local and foreign commerce to and from the cities that are directly connected with it, make it most necessary that it should never fall into the hands of an enemy.

Aside from the great injury that it would inflict upon us to have an enemy hold this bay, it would also be important for him to do so, because it furnishes a safe anchorage, which is accessible at all times, for any number of ships. It occupies a central position on the coast, which could be used as a rendezvous for his fleet and for his supply-vessels, and from which he could operate, both by sending out cruisers to intercept the coasting and West India trade, and by making it a point of departure for an attack upon any part of the coast. Next to Long Island Sound, it would be the most important place on our coast to an enemy, as furnishing a safe and commodious anchorage, and a central position at which to receive supplies of coal and ammunition. And, in addition to all this, it would deprive us of one of our best equipped navy-yards, which occupies an important strategical position.

The entrance to this bay is too broad to be protected by forts. Although any vessel passing the capes must approach Cape Henry to within five miles, and although the water is only four or five fathoms deep at a distance from the cape, it is too great either to injure a ship by gun-fire, or to protect submarine mines by gun-fire, if the passage were so obstructed. We are, therefore, forced to resort to floating defenses in order to retain possession of this bay and to protect its commerce. The cities of Washington, Baltimore, and Norfolk can be protected by forts. It is thought that what is required of the naval defense would be accomplished by the following vessels:

No. of Vessels.	Type.	Guns.			Cost.
		10-inch.	12-inch.	14-inch.	
1	1st	2	...	2	$3,500,000
2	3d	4	4	...	4,400,000
3	Rams	...	...	...	3,000,000
15	Torpedo-boats	...	...	...	1,500,000
					$12,400,000

The 7th Section in this scheme of defense includes the remainder of the Atlantic coast from Charleston southward, and therefore the harbors of Charleston, Port Royal, Savannah, and also Cumberland Sound (should the entrance be improved in the future and this beautiful sound be made as important as its position, both commercially and strategically, should make it). Charleston is a port of considerable commercial importance, and sufficient means must be provided to prevent its blockade. The city is about seven miles from deep water, and any vessel taking that position to bombard would be three miles from any possible fortification. The city might, therefore, be bombarded. As there are but 14 feet of water in the channel, which is readily defended by both guns and submarine mines, the harbor is safe against capture. Unless the entrance is considerably deepened by the jetties now constructing, it would not be practicable to use any but light-draught vessels for the defense of this port. But to prevent the blockade of either this port or Savannah, it is thought best to station the naval defense of both these ports at Port Royal. Only 17 feet can be carried over the bar at Savannah, and only very light-draught vessels can approach within ten miles of the city. The port can, therefore, be completely defended by forts.

The entrance to Charleston harbor is about 55 miles to the northward of the eastern entrance to Port Royal, and the entrance to the harbor of Savannah is about ten miles to the southward of the southern entrance of Port Royal. 21 feet can be carried through either entrance at Port Royal, and there is interior communication to both Charleston and Savannah for torpedo-boats. Therefore, if we have a proper naval force stationed at Port Royal, it would be able to prevent the blockade of either of these ports and the bombardment of Charleston, although the vessels themselves might not be able to enter either port at all tides. While Port Royal is a place of little commercial importance, it will be necessary to defend it by suitable fortifications, in order that it may be a harbor of refuge for our own vessels if overtaken by a superior force, and also a refuge for coasting vessels. When we consider the office of our cruising fleet in the defense of the coast, we shall see that this harbor is a most important one. Doubtless, if an enemy should find a number of our vessels in this harbor, it would be desirable to blockade them. But to do this would require a force superior to the one blockaded, so that it would become a question whether it would pay the enemy to undertake such a blockade; for it must be remembered that assistance could probably be sent to the blockaded vessels that would reverse the inequality of the forces. There being, at present, no commercial interests to protect at this place, it is thought that all needed protection may be furnished by proper fortifications.

The following vessels would be sufficient protection for this section:

No. of Vessels.	Type.	Guns.		Cost.
		10-inch.	12-inch.	
2	3d	4	4	$4,400,000
2	Rams	...	...	2,000,000
20	Torpedo-boats	...	...	2,000,000
				$8,400,000

No other ports on the Atlantic coast have sufficient water to permit the entrance or approach of a hostile vessel that could not be driven off by light batteries on shore. No other ports would tempt an enemy to blockade while the larger ports were open to trade.

GULF COAST.

On the Gulf Coast the ports to be defended are few, but widely separated. Means provided for the defense of one port cannot assist in the defense of another, except in the case of Pensacola and Mobile. The strategical importance of Key West makes it necessary to fortify this port in a thorough manner, in order that it may be a refuge for our cruising vessels and a point from which to conduct operations in the Gulf. It commands the passage to our Gulf coast, and near it must pass all the Gulf trade. Its exposed position unfits it for an extensive naval station, requiring expensive constructions that might be destroyed by bombardment. It should, however, be provided with means for making all ordinary repairs not requiring the docking of a vessel or the removal of her engines or boilers. The commercial character of the place renders any naval defense unnecessary. Key West is about 500 miles from Pensacola or New Orleans, so that much valuable time would be saved to vessels operating in the vicinity of Key West if it were provided with suitable repair shops. It will also be an important coaling station.

Tampa Bay, 230 miles north of Key West, affords excellent anchorage for vessels less than 21 feet draught. St. Joseph's Bay, 100 miles west of Pensacola, is also a secure and commodious harbor for vessels of 18 feet draught. Neither of these places, however, is of any commercial or strategic importance at present, and no defense need be provided.

The bay of Pensacola and the naval station near the mouth of that bay present a case, which, I think, can be disposed of in only one way, by the removal of the station to some other place where it can be protected. If a suitable place can be found at New Orleans, I think it would be preferable to any other point in the Gulf. In the first place, it would be beyond the reach of an enemy; it would have ample communication with the sources of supply, and the population and facilities of a great city to draw upon. Pensacola has neither of these, and it would seem impracticable to undertake successfully and economically any shipbuilding or repairs at a place that is so cut off from all the iron industries of the country, upon which it must depend for supplies, and situated in a sparsely populated part of the country, where every mechanic would have to be imported, and where he would be without employment if temporarily discharged by the government. When ships were built of oak there was a reason for placing a navy-yard in the woods, but that reason no longer exists. New Orleans is quite as central as Pensacola. The latter port must be defended to secure the port to our own use and to protect the city, and this can be done by suitable fortifications if the navy-yard is removed. If the yard remains, it can be protected only by a considerable naval force. The yard can be approached to within two miles in deep water, without entering the harbor. I consider it so unwise to continue a navy-yard in such a position that no defense is proposed. Even if the yard were removed to the head of the bay, it would still be within six miles of deep water, while all the other objections to the location would remain.

Mobile Bay, 40 miles west of Pensacola, is an important commercial city, and, together with the adjacent waters, constitutes the 8th Section. It can be perfectly defended by fortifications that will also close the bay against any enemy. But, owing to the extent of the trade of the city, it would be an important place to blockade. To prevent this under the conditions likely to arise, and at the same time furnish protection to the towns along the shores of Mississippi Sound and the trade of that sound, it is thought the following vessels will be sufficient:

No. of Vessels.	Types.	10-inch Guns.	Cost.
3	Gunboats	3	$ 600,000
10	Torpedo-boats	...	1,000,000
			$1,600,000

Since modern guns require such heavy emplacements, engineers do not consider it practicable to construct forts on the banks of the Mississippi below the city of New Orleans; the defense of the city must then be entirely naval. Owing to the contracted and lengthy channel this is not a difficult matter. Two vessels of the first type would be sufficient for this purpose, in connection with torpedo-boats and the necessary submarine mines and their protecting batteries. Two plans of defense are possible: (1) to obstruct all the passes with mines, except the South pass, and make the defense at the head of the passes, where there is ample space for manœuvring, while the enemy is restricted to the narrow pass, and consequently to the use of not more than two vessels; (2) if no suitable ground can be found for the batteries to protect mines, and for observing stations, below the passes, then the passes can be left open and the defense made higher up the river; for no armor-clad could enter at any but South pass, while the other passes could be used by our own torpedo-boats. The following defense is, therefore, recommended for this, the 9th Section:

No. of Vessels.	Type.	Guns.			Cost.
		10-inch.	12-inch.	14-inch.	
2	1st	4	...	4	$7,000,000
1	2d	2	2	...	3,000,000
1	Ram	...	...	...	1,000,000
10	Torpedo-boats	...	...	...	1,000,000
					$12,000,000

This force would be sufficient to protect the city against any fleet and prevent the blockade of the port except by a superior force of armor-clads; and the manner of meeting such a contingency must devolve upon the cruising fleet.

The only other important port of the Gulf is Galveston, 300 miles west of the Mississippi. The shoal water at the entrance, 11 feet, and the close proximity of the city to the sea, render it impracticable to make any thorough defense of the city. No guns could be placed on shore that could protect the city from bombardment. The shoal water on the bar, 13 feet under the most favorable circumstances, renders it impracticable to employ vessels mounting heavy guns and drawing more than 11 feet water. A fleet of gunboats and torpedo-boats might be used to make a fight, but they could not protect the city unless they were superior to the attacking fleet. It would then become a question of how many gun and torpedo-boats could be allotted to the defense of this city. The greater the number, the greater must be the force that would venture to attack it. At present I would recommend only shore-batteries mounting a few heavy guns, and 5 torpedo-boats.

PACIFIC COAST.

The naval defenses of the Pacific Coast may, for the present, be comprehended in the defenses of the towns and cities situated on the shores of San Francisco Bay and Puget Sound. The registered and enrolled tonnage of San Francisco is greater than that of any port of the United States except New York, and the tonnage duties paid to the United States were greater at San Francisco during the past year than at any other port except New York. At the completion of the canal connecting the Atlantic and the Pacific, San Francisco will lose part of the trade that she now enjoys, yet must continue the emporium of a vast country, which is to grow greatly in wealth and population. Indeed, the increase of trade that will come to San Francisco through the canal may more than balance what is lost through the same cause. Every consideration indicates that San Francisco is to be a great city, and it is important that it should have ample protection, because of its present importance as well as its future greatness.

The bay of San Francisco is only one mile wide at its entrance, but the water is sixty (60) fathoms deep at the same point, which renders the use of mines uncertain. It is probable, however, that the bay could be defended by forts against capture. But forts could not be placed to protect the city from bombardment. Next to New York, it is the most important port to secure against blockade. This object can be accomplished only by a naval force. Owing to the fact that no assistance can be sent from any other part of the coast, it is necessary that the vessels assigned to this duty should be more numerous than if it were possible to combine the defenses of two or more sections to meet an enemy that might be of considerable strength, as may be done at points on the Atlantic coast. It is also necessary in order to protect the smaller places growing up to the southward of San Francisco, none of which can be protected by land defenses. It is therefore considered necessary to station the following vessels at this point:

No. of Vessels.	Type.	Guns. 14-inch.	 12-inch.	 10-inch.	Cost.
3	1st	6	...	6	$10,500,000
2	Rams	...	...	...	2,000,000
15	Torpedo-boats	...	...	...	1,500,000

The important places on the Columbia River need no naval protection except to prevent a blockade. For this purpose it will be necessary to station a sufficient force in Puget Sound, which can act to protect both the sound and the Columbia River against blockade.

Puget Sound is rapidly growing in importance, and is destined to become the site of an important naval station. The tonnage of this sound reported for the past year makes it rank next after that of New Jersey, and, according to States, it ranks eighth in the Union. The present isolated position of this part of our country, its proximity to the boundary, the fact that it faces a strongly fortified naval station of England at Victoria, renders it prudent to provide an adequate defense. Suitable land defenses should be at once placed at the narrowest part of Admiralty Inlet, and the magnitude of the naval defenses should keep pace with the growing commerce of the locality, in order that it may have unobstructed ingress and egress. The present promise of this commerce demands that no less than the following should be provided :

No. of Vessels.	Type.	Guns. 14-inch.	 10-inch.	Cost.
2	1st	4	4	$7,000,000
15	Torpedo-boats	...	...	1,500,000

San Francisco and Puget Sound would constitute the 10th and 11th sections in this scheme of defense, and should constitute a separate command, under one officer, like the Atlantic Coast, and have section commanders as there provided.

LAKE FRONTIER.

The arrangement existing between the United States and Great Britain since 1817, whereby the naval force maintained on the lakes by either party is limited to two small vessels of 100 tons each, renders any suggestion regarding the defense of our lake frontier impracticable, so long as that arrangement continues. It was effected at the solicitation of the United States Government, at a time when the shores of the northwestern lakes were almost entirely unsettled. Neither party to the arrangement had any considerable interests at stake along the shores. At the present time the conditions have completely changed. Large cities have grown up along the shore on the American side, while there are none on the Canadian. England has constructed several ship-canals, which afford uninterrupted communication from the sea to the extreme points of the upper lakes. The United States has no means of passing from the sea to the lakes, or from Lake Ontario to the upper lakes, except through Canadian territory. England can, on short notice, send a large fleet of gunboats directly into the lakes, while the United States would be obliged first to build a shipyard, and then to construct vessels. In other words, our lake cities are now the most defenseless portion of our coast, completely at the mercy of England, and they must thus remain, so long as the arrangement above referred to continues in force.

The growth of American commerce on the lakes may be inferred from the fact that 46 per cent of the tonnage built in the country during the past year was upon the lakes, and the tonnage built has more than doubled each year for the past three years. It now amounts to nearly 900,000 tons, which is more than double that of the whole Pacific Coast, and one-third that of the whole Atlantic and Gulf coasts. It will be seen that our interests on this frontier are not only great and exposed, but they are yearly becoming more valuable, and no steps are taken to protect them.

Shortly after the war of 1812, England saw the military necessity of uninterrupted communication with the lakes in case of another difficulty. At the same time the commercial importance of such a route was very manifest. Quebec hoped thereby to secure the western trade, and although the development of our railroads and the Erie Canal have retained the trade within our own borders, and continued New York as the great commercial center of the country, yet all the advantage which by our enterprise we have secured along these lines is being hourly hazarded so long as we leave the great cities of the lakes open to destruction, in case of a war with England. That country now possesses 100 gunboats that can pass through the St. Lawrence canals and to the upper lakes. It may be urged that we could easily render useless some of these canals by destroying some of the locks, and that we could certainly secure everything beyond Lake Huron, as the Sault Ste. Marie Canal is in our own territory. But we must remember that war creeps upon us in most unexpected ways. To destroy one of these canals would be an act of hostility, and we might find ourselves in the embarrassing position requiring us to perform the *first hostile* act, or permitting vessels to pass through these canals while we still hoped that the threatening difficulty might be settled without hostilities.

There is not now any plan or provision made to prevent armed vessels from passing into these lakes. Who will assume the responsibility of destroying these canals when it is feared that we may become involved in war with England? To wait until war is certain, is, assuredly, to wait too long. No active hostilities could certainly be inferred from the fact that England sent armed vessels into these waters, notwithstanding such act was contrary to the treaty. England might say that her action was only to make it more *desirable* for us to yield to her wishes regarding the matter in dispute.

From every point of view, good statesmanship requires that the arrangement of 1817 should be terminated. We have great interests in jeopardy by its continuance, and we are powerless to protect them. England has little at stake under any circumstances, and at the same time is in a position to inflict the greatest injury upon us. She ought certainly to recognize the reasonableness of our desire to put an end to an arrangement so manifestly to our disadvantage, and therefore the friendly relations now existing between the two countries should not be in the least marred. Even those who are looking forward to a union between the United States and Canada should find no objection to what would, in such a case, be a temporary insurance of the interests we have upon the lake frontier.

Should the arrangement of 1817 be terminated, it might be replaced by another made upon a basis recognizing our paramount interests in the upper lakes. If a satisfactory understanding could not be reached, then each nation would be left to protect her own cities and commerce as she might see fit. Doubtless, this would result in providing some adequate protection for the great cities on our lake frontier, and England would not consider it necessary to compete with us in this matter, because Canadian interests would not warrant it. An arrangement that would be satisfactory to this country would consist in terminating the 1817 arrangement with regard to Lake Ontario, leaving it in force with reference to the upper lakes.

We should then construct upon Ontario at least five (5) vessels, each of which should be greatly superior to any vessels able to pass up the St. Lawrence. These vessels may be of 2500 tons displacement, mounting a suitable number of 6-inch guns, and possessing good speed and manœuvring power. Then, with practically no armed vessels upon the upper lakes belonging to either party, and a sufficient force upon Ontario to make certain that the arrangement shall, under all circumstances, be observed, I believe the whole question of the defenses of lake frontier would be settled.

Vessels of sufficient draught to prevent them from passing the Welland Canal are recommended, in order to constitute an assurance to England that they would not be used upon the upper lakes. The two countries would then be placed upon an approximate equality. England would still have some advantage in being able to send small vessels up the St. Lawrence into Lake Ontario, while the United States must build her vessels on the spot. On the other hand, the overwhelmingly greater interests at stake would lead the United States to provide a force sufficient always to command the situation. The naval force required to ensure our supremacy would not be great. A few vessels of the type above indicated would easily destroy any number of vessels England might attempt to send up the St. Lawrence. She would, therefore, be forced to build upon the lake any vessels that could hope to compete with those we would build, and the upper lakes would be secure against intrusion from any such vessels, because they could not pass the Welland Canal. As nearly all our great cities and our principal lake commerce to be protected are upon these upper lakes, this scheme seems satisfactory from every point of view. This lake would constitute the 12th Section.

It may be objected to this general scheme of coast defense that, if it is necessary to build such a considerable fleet of armored ships, it would be better to keep them together as a fleet and send them to meet the enemy, or, at least, to be ready to move from some central point to any place that might be threatened. It might be said that we should, in this way, be reasonably certain to outnumber the enemy at any point at which he might appear. The answer to this doubt may be found in the question, "What could be done if the enemy threatened two or more points at once?" Would it not, then, become necessary to divide the fleet into as many parts as there were places threatened? At least, would it not be necessary to dispatch to each point a greater number of ships than the enemy had at each, and thus eventually divide the fleet? If the ships were kept together, they would have to travel from one extremity of the coast to the other in pursuit of the enemy, which, being driven from one position, would re-appear in the most unexpected places.

It seems to be the present policy of England to rely upon her great fleet for the defense of her coast, rather than to localize the defense. England would, in case of war, attempt to blockade the ships of her enemy in his own ports, and in this manner prevent an attack upon her coast. This has the merit that it is an offensive defense. In order, however, that it may be successful, the navy that undertakes it must be greatly superior to her enemy. On the other hand, the manœuvres of the English squadrons last summer throw considerable doubt upon the efficiency of such a blockade. It will be remembered that vessels from the Irish squadrons had no difficulty in escaping from the blockading fleet. A part of the Irish squadrons having escaped, the English admirals became alarmed, for they realized that the coast of England was unprotected and that the escaped vessels might attack it with impunity. The blockades were consequently raised and the English squadrons departed in haste for the protection of London, that being the most important place needing their services. In this way they gave entire freedom to the Irish squadrons, and left the greater portion of the English coast at the mercy of the enemy.

I think the British authorities must be convinced that even a much inferior squadron cannot be blockaded, and that, in consequence, if their coast requires naval defenses at any point, that naval force must be on the spot. No matter how great the naval power of a nation, it cannot give protection to two widely separated points unless it occupies both of them. The moral effect of a great navy is not alone sufficient to give protection after war has commenced. The celerity of movement now possessed by ships is greatly in favor of those eluding pursuit; so that no matter what the disparity in the naval strength, the stronger can furnish complete protection against the weaker only by its presence at all points liable to attack.

I find it difficult to understand the reasoning that guides much of the naval opinion in England at the present time, where the defense of the coast is made to depend upon a complete mastery of the sea. Although England must possess the most powerful navy in the world if she is to retain her extensive and widely separated possessions, yet it would appear to simplify the problem very much if every advantage were taken of the protection afforded by land defenses. There is a fallacy in the reasoning that coast defenses are not required until the fleet has been destroyed.

Again, it must be remembered that in the scheme here proposed, the defenses of the whole coast can be assembled to meet the combined fleet of the enemy when occasion demands it. The vessels possess excellent sea-qualities and ample endurance for operations along the whole coast. In addition, such a fleet would have the ability of acting together as no other fleet in the world, as now constituted, could do. It will be noticed that the types of armored vessels closely resemble each other in speed, armor, armament, turning power, and best point for fighting. They would, therefore, constitute a homogeneous fleet capable of acting in harmony, in accordance with rules, and would be more than a match for a more powerful fleet made up of various types of vessels, differing in these important qualities where some are constructed to fight bows on, others broadside on, and all varying in speed and turning power. While the vessels are distributed along the coast, they are at all times in a position to seek the protection of the forts when pressed by a superior force.

No scheme of defense would be efficient without ample provision for supplying the vessels with men and coals, the two essentials for keeping the ships in fighting condition. To man this fleet of coast-defense vessels, including torpedo-boats, would require 13,400 men. Two-thirds of this number should be furnished by the naval militia in time of war, and as far as practicable the vessels of each section should be manned by men recruited from the section to which they are assigned. This would have the double advantage of having the vessels convenient for the annual drills to which the Naval Reserve should be subjected in peace times, and it would also secure to the service the local knowledge of the coast possessed by the naval militia, which would be of the first importance. The balance of the crew, in time of war, should be officers of the regular service and men well trained by long service. In time of peace so many of each type of vessel should be kept in commission as would serve as schools for the Naval Reserve, the officers and a portion of the men being taken from the regular service. It would be the duty of the latter to receive on board that portion of the Naval Reserve detailed to man that particular type of vessel in that particular section of the coast, and to complete the crew organization and drill them in their duties. It will be seen that with a little care and forethought such a crew might arrive on board with their billets in hand and ready to go directly to their stations.

The action that has been taken, both by the Department and in

Congress, to enroll the naval militia and to organize a Naval Reserve, is of the utmost importance to the country. Without this, it would be impossible to man our ships in time of war. The plan recommended by the Navy Department and formulated in the Whitthorne Bill would furnish a large force that would become identified with the navy and look forward to service afloat in case of war.

I venture to suggest some modifications in the plan proposed by the Department, which is to make the reserves all National Reserves, and to make the basis of each organization the ship instead of the battalion. The reason for placing the reserves directly under the national government is because the ships in which they must serve, and the weapons they must use, and the engines they must handle, must belong to the national government and remain under its control. In this respect the present militia organizations of the several States differ essentially from what is required of a Naval Reserve. The land militia is, most properly, organized into companies, battalions, or regiments; and when furnished with arms and other personal equipments, the organization is complete and effective. On the other hand, the weapons and instruments that a Naval Reserve must use are complicated in the extreme; each weapon demands for its use the combined efforts of many men. It would be impracticable to train each man in the duties of all the others, so that there must result many classes of duty; as that of gunners, torpedo-men, engineers, firemen, helmsmen, and many other minor sets of duties that it might be necessary to treat as quite distinct duties in drilling a Naval Reserve, where the time available would necessarily be so limited.

If the coast-defense vessels here recommended were provided, the naval reserve of each section could be organized into the necessary ship's companies, and be assembled at the most convenient time for the annual drill. In this way it would seem that there must result all the advantages which belong to a home organization for home defense, while at the same time it would be under the direct management of the general government. It would be most desirable to provide for a drill on shore as a battalion at other times than the annual drill, in order to create an *esprit du corps*. The organization should then be the same as that of a ship's company landed for the purpose of such a drill. The battalion might be officered entirely by members of the reserve for such drills, and they should be given the use of their uniforms and small-arms. In this way all the necessary exercise at small-arms would be obtained, and the ship's company would be brought together frequently during the year, and there would be developed a personal pride in the efficiency of each organization. It is not necessary that seafaring men alone should enter the naval reserve; for any young intelligent man would be at no disadvantage in learning the duties of many important stations on board a modern ship.

A *large* reserve is needed in order that a sufficient number may be at home ready for a call. Our navy-yards and naval stations would be admirable places of rendezvous for such organizations. They would there have, without expense either to themselves or the government, all the facilities that the crack regiments of the National Guard now have in their beautiful armories, and, in addition, they would be surrounded by all the appliances they would have to deal with on board ship. The large resources of our navy-yards for transporting the men to and from the yards would render the assembling of the men for exercise an easy matter. The Navy Department could detail one or more officers for each ship's company, to give them instructions not only as a battalion, but also to prepare them for their duties on board ship.

The character of the naval as compared with the military service demands that the Naval Reserve should have a closer touch with the active navy than is required between the army and the land militia, and I think the organization here proposed would secure that end, and might be inaugurated immediately upon the passage of such a bill as that introduced by Mr. Whitthorne. The fact that the initial steps would then devolve upon the Navy Department would ensure prompt action and the best results that could be obtained. This is intended as the merest outline, and must be taken in connection with what has been published by the Navy Department and the action already taken by some of the States to provide for a Naval Reserve.

To provide proper coaling facilities for a coast-defense fleet would seem to be an easy matter, but it should not, therefore, be neglected. The long distances covered by a ship in a few hours show how important the element of time will be in everything connected with the fleet. The defense has an enormous advantage in this matter, and it should be taken advantage of to the utmost extent. Coaling stations should be established at short distances along the whole coast. The situation and appliances for coaling should be such that a vessel would not have to go far from the field of her operations, and that the coal could be put on board of as many vessels as would be likely to require coal at once, and in a very short space of time.

Since the supply of ammunition that a vessel can carry is small, it might be found advantageous to associate the coaling station and magazine; for, in any case, both must be defended. It is not sufficient that coal is now to be had at our navy-yards. Several of these are too far from the naval line of defense, as at League Island and Norfolk yards. Coal should be provided at the mouth of the Delaware and at Fort Monroe. The defenses required would not be great, for the temptation to destroy them would not be great. If every facility for coaling is provided at such stations, the supply of coal need never be great, even in time of war, and none need be kept on hand in time of peace.

It is almost needless to add, in this connection, that the docking facilities at our navy-yards should be greatly increased. We now have but three docks—one at the New York yard, one at Norfolk, and one at San Francisco—that are large enough to take in the 1st type of vessel recommended in this scheme. There are two other private docks in New York that are also large enough.

It needs no argument to prove that every available means should be at the disposal of the Navy Department in providing a naval defense. Hence this outline would be incomplete if I failed to point out the service that might be rendered by the Revenue Marine, the Coast Survey, and the Life-saving Service, in assisting in such a defense. The personnel of each of these would constitute an invaluable addition to the navy in time of war. Although the vessels belonging to the Revenue Marine and the Coast Survey are not suitable for fighting ships, there is no good reason why they should not be so constructed. Ships built to carry passengers and freight are not suitable for carrying guns; and although steamship companies may be induced to modify the construction of their ships for this purpose, yet it would require a large subsidy to induce them to modify the design of their hulls and engines to suit the ships to war purposes. But when it becomes necessary for the government to build vessels for the purposes required in the Revenue Marine and Coast Survey, it would seem to be only reasonable that their engines should be protected and the ships fitted to carry a battery suited to their capacity. Nor would it detract from the efficient performance of their present duties if the crews were drilled in the use of these weapons. If there were no other reasons why these branches of the government service should be placed under the Navy Department, it would be a sufficient reason that they would strengthen our naval defense in time of war.

APPENDIX.

GENERAL DESCRIPTION OF TYPE VESSELS FOR THE DEFENSE OF THE COASTS OF THE UNITED STATES.

The general types of vessels for the coast defense have been taken, with certain modifications, from the report of the Board on Fortifications and other Defenses, 1885, to which the reader is referred for further particulars.

FIRST TYPE.

The first and most powerful vessel has been designed to satisfy the following conditions:

Draught of water not to exceed 19 feet.

To carry two 14-inch B. L. R. guns in the complete protection of a turret suitably armored, mounted high enough above water to be fought in moderately heavy weather.

Two armor-piercing guns of lighter caliber, to be carried with suitable armor protection, and mounted so as to be served with the greatest rapidity; these guns also able to command the greatest possible train.

A fairly powerful secondary battery, with suitable shield and bulwark protection and well protected ammunition lead, to be also carried.

A suitable installation of automobile torpedoes, expelled under water, to be provided, while as complete protection as possible against torpedo attack shall be provided in the hull.

Buoyancy and stability shall be ensured against heavy gun-fire by a water-line belt of 16-inch armor, of length about 50 per cent of the length of vessel, between perpendiculars, terminating in athwartship bulkheads of suitable thickness, and protection to be continued to the ends of the vessel by under-water decks about 3 inches thick and suitably supported. Deck plating of 2¾ inches to be worked over the belt. Provision against swash to be made by wing coal-bunkers or otherwise over the armored decks.

Protection for the turret-base and loading gear to be provided by an armored redoubt or turret-chamber, of about 15-inch armor, extending to suitable height. Armored erections to be supported and give support to one another, so that as little dependence as possible may be necessary on unarmored supports, and to be located so as to interfere as little as possible with the train of the guns, and present the smallest possible target.

The vessel to have a maximum speed in smooth water of not less than 15¼ knots under trial conditions, with forced draft.

The coal supply at load displacement to be sufficient for a somewhat greater distance than 1500 knots, at a speed of 10 knots in fair weather, with bunker capacity for a greater supply.

The vessel designed to meet these conditions has the following principal dimensions: Length over all, 330 feet 5 inches; length between perpendiculars, 310 feet; beam, extreme, 63 feet; molded depth, 29 feet 10 inches; draught, mean and extreme, 19 feet; displacement, 6500 tons; freeboard, to top of main deck at side over belt, 10 feet 4 inches; freeboard, to top of main deck, aft, 5 feet 9 inches; armored freeboard, in wake of belt, 2 feet 10 inches; length of belt, 160 feet; proportion of water-line area enclosed by belt, 67 per cent; maximum I. H. P. (forced draft), 6500; maximum speed, 15.6 knots.

ARMAMENT.

Two 75-ton 14-inch breech-loading rifles, in revolving turret, forward, having complete train around the bow, and 90° abaft port beam, and 67° abaft starboard beam. Thickness of armor on turret, 16″ + 1½″. Thickness of armor on forward half-circle of redoubt, 15″ + 1½″; on sides and after end, 14″ + 1½″. Height of center of guns above L. W. L., 16′ 0″. Two 26-ton 10-inch B. L. R. in barbette aft, echeloned to starboard, with train around the stern from right ahead to 30° forward of port beam. Barbette armor 11″ + 1″ front and sides, 9″ + 1″ rear, to extend from the armored deck to 3 feet above the main deck. Height of center of guns above L. W. L., 14 feet 9 inches. Overhead screen, 2″ thick.

Secondary battery to consist of four 6-pounder R. F. guns, two 1-pounder R. F. guns, one 37-mm. revolver in military top, four short Gatlings.

Torpedo armament to consist of five underwater fixed torpedo tubes; one in the stern, two at 45° forward, at fore-corners of belt, and two athwartships, abaft the belt.

HULL ARMOR.

Top of belt above water, 2 feet 10 inches; depth below water, 4 feet 1¾ inches; thickness on sides, 16″ + 2″; thickness on forward bulkhead, 15″ + 1¾″; thickness on after bulkhead, 14″ + 1¾″;

thickness of armored deck over belt, 2¾″; thickness of armored deck forward of belt, 3″; thickness on armored deck abaft belt, 3″ and 2¾″.

All deck openings protected by glacis, cofferdams, and shell-proof gratings.

Thickness of armored conning-tower, 14 inches. Thickness of armor on armored hatchway on rear of redoubt and supporting conning-tower, 12 inches and 9 inches.

MOTIVE POWER.

Boilers.—To be capable of making steam of 150 pounds gauge-pressure for 7500 I. H. P. under forced draft. The main boilers to be 4 in number, 14 feet diameter, two of double-ended cylindrical type, 17 feet long; and two single-ended, 9 feet 9 inches long. One single and double-ended boiler to be in the same compartment on each side of the middle-line bulkhead. Single boilers next the engines; fire-rooms athwartships. The double-ended boilers to be served by one stack, the single-ended by another, the uptakes joining above the armored deck. Twenty-four 36-inch furnaces with an aggregate grate surface of 400 sq. feet; aggregate heating surface of 12,750 sq. feet.

Engines.—To be three-cylinder, triple expansion, vertical engines, driving twin screws. Cylinders, 33¼-inch, 48½-inch, 73-inch diameter; stroke, 40 inches; revolutions per minute, 95 at maximum trial speed of 15.6 knots. Engine driving each screw to be in separate compartment formed by middle-line bulkhead.

Screws of manganese bronze, four-bladed, 15 feet 6 inches diameter, of uniform pitch of 19 feet 4½ inches; developed area of blades of each screw, 60 square feet.

Donkey Boiler.—A boiler of approved pattern suitable for using salt water, with about 20 square feet grate, to be carried on the armored deck, capable of making steam for ordinary ventilation, heating, lighting, hoisting, pumping and distilling purposes, and arranged to assist the main boilers in getting under way.

Total Weight of Propelling Machinery, with water, stores, spare parts, and donkey engine as above, to be 650 tons.

Speed and Coal Endurance.—With 6500 I. H. P., a speed of 15.6 knots should be obtained under measured mile trial conditions at the load displacement of 6500 tons. With boiler-power provided, having in view the power provided for auxiliaries, especially in action, a speed of 15 knots should be continuously maintained in smooth water without difficulty. At this speed the coal supply of 300 tons at load displacement would suffice for 60 hours' steaming, covering a distance of 900 knots. With 550 tons coal, which may be readily carried, the distance which could be steamed at 15 knots would be about 1500 knots. With 1300 I. H. P. a speed of 10 knots will be obtained in smooth water, when 300 tons coal will suffice for 2500 knots, about ten days' steaming. With 550 tons about 4800 knots would be covered at 10 knots.

DISTRIBUTION OF DISPLACEMENT.

The displacement is distributed among the various elements of efficiency as follows, and, for comparison, the corresponding figures are given for two representative foreign war-ships of about the same proportionate freeboard and capacity to fight their guns in heavy weather. The Dreadnought, however, not being intended for the coast defense, has more endurance:

Ship.	Dreadnought. Iron.	Tempête. Iron and Steel.	1st Type. Steel.
Hull,	31 per cent.	40 per cent.	35 per cent.
Protection,	36 “	39 “	38½ “
Armament and Ammunition,	5 “	6 “	8 “
Propelling Machinery,	13 “	9 “	10 “
Coal,	11 “	3 “	4⅔ “
Equipment,	4 “	3 “	3¾ “

COST.

The estimated cost of hull and machinery, exclusive of armament, its immediate fittings and ammunition, is $2,950,000. With armament complete, ammunition, torpedoes and torpedo apparatus, and the vessel complete and ready for sea in all respects, the estimated cost is $3,575,000.

SECOND TYPE.

For use in Sections 1, 2 and 3, namely, from Eastport, Maine, to New York City, a design is proposed embodying the same general features as first type, except that the 14-inch guns are replaced by 12-inch, and all limitation removed from the draught of water. Such a ship would weigh about 5700 tons and cost, ready for sea in all respects, about $3,000,000.

THIRD TYPE.

This vessel has been designed to satisfy the following conditions: The vessel to be specially adapted to harbor defense and comparatively smooth water work, to which end her freeboard may be small, and the heaviest fire and protection should be forward. Manœuvring power well developed and the bow adapted to ramming. A fairly powerful installation of automobile torpedoes, expelled under water, from positions favorable to attack, to be provided, while as much protection from similar attack is given as is possible in the hull. As powerful a secondary battery to be fitted as may be fought under reasonable cover, with special regard to protected ammunition supply. The heavy battery to be so mounted as to obtain the greatest range and accuracy of fire possible, and the forward guns to be fully protected by a turret. The vessel to have sufficient power for a maximum speed in smooth water of not less than thirteen knots. Though it is not considered that with her low freeboard this speed could be obtained even in comparatively smooth water, the necessary power is demanded for handiness. Also it is considered that vessels with greater deep-water speed will not utilize it fully under the conditions of warfare over the shoals and bars in contracted harbors and their approaches. Her draught should be the least consistent with housing screws of size suitable for the necessary motive-power. The vertical armor to be confined to such dimensions as will permit a sufficiency of buoyancy and stability to be retained after the maximum amount of injury possible in the unarmored portions has been inflicted, and its thickness to be the maximum possible. Outside the belt, the buoyancy to be protected by thick deck-plating, presenting a small inclination to the horizontal in the neighborhood of the water-line, and the water-line to be further supported by a belt of cork or cellulose or other water-excluding material, especially forward. The same considerations as regards armored erections obtain as in First Type. The coal supply at load displacement to be sufficient for a distance of 1000 miles at ten knots in fair weather, with bunker capacity for a greater supply.

The vessel designed to meet these conditions has the following principal dimensions: Length between perpendiculars, 260′; beam, extreme, 57′ 6″; mean draught, 14′ 6″; molded depth, 18′ 3″; displacement in tons, 4018; freeboard at side to top of deck-plating, 3′; freeboard at side to top of wood flat, 3′ 3″; length of belt on side, 131′ 7″; length of belt from end to end of bulkheads, 155′ 2″; proportion of

W. L. area enclosed by belt, 70 per cent; percentage of armored reserve buoyancy, 16½ per cent; max. I. H. P. (forced draft), 3500; maximum speed, 13 knots.

ARMAMENT.

Two 44-ton 12-inch B. L. R. in revolving turret forward, echeloned to port, having complete train around the bow to 85° abaft the port beam and 65° abaft starboard beam. Thickness of turret armor, port plates 16″ + 1½″, rear plates 14″ + 1½″. Height of center of guns above L. W. L., 7′ 6″.

Two 26-ton 10-inch B. L. R. in barbette aft, echeloned to starboard, with complete train around the stern to 90° forward of starboard beam and 67° forward of port beam. Barbette armor 11½″ + 1″. Overhead screen, 2″. Height of center of guns above L. W. L., 12′.

Secondary battery to consist of two 6-pounder R. F. guns, two 1-pounder R. F. guns, one 37-mm. revolver in military top, and three short Gatlings.

Torpedo armament to consist of three underwater fixed torpedo tubes, one in the stem and two at 45° forward of beam under the armor deck forward.

HULL ARMOR.

Top of belt above water, 3′ 0″; depth below water, 4′; thickness on sides, 12½″ + 1½″; thickness on forward bulkhead, 13″ + 1½″; thickness on after bulkhead, 10″ + 1″; thickness on armor deck over belt, 2½″; thickness on armor deck forward of belt, 3″; thickness on armor deck abaft of belt, 2½″; thickness of armored conning-tower, 12″; thickness of armored ventilating shaft, 6″ and 9″; thickness of armored stack, 4″.

All openings to be provided with glacis plates and, except to armored erections, with shell-proof gratings and cofferdams.

MOTIVE POWER.

Boilers.—To make steam of 150 lbs. gauge-pressure for 3500 I. H. P. under forced draft. The main boilers to be three in number, of the low cylindrical type, 11′ in diameter and 19′ long; to be in one compartment and, together with the donkey boiler, to be served by a single armored stack. Nine 42″ furnaces, with an aggregate grate surface of 200 square feet. Aggregate heating surface, 7000 square feet.

Donkey Boiler.—A boiler of approved pattern, suitable for using salt water, with about 25 square feet of grate, to be provided, capable of making steam for ordinary ventilation, heating, lighting, hoisting, pumping, and distilling purposes, and arranged to assist the main boilers in getting under way.

Engines.—To be 3-cylinder, triple expansion, horizontal engines, driving twin screws. Cylinders 25″, 37″, and 55″ by 36″ stroke. Revolutions per minute at maximum trial speed of 14 knots = 101. Engine driving each screw to be in separate compartment.

Screws.—To be of manganese bronze, 4-bladed, 13′ diameter, of uniform pitch of 16′ 3″; developed area of blades of each screw, 42 square feet.

Total Weight of Propelling Machinery.—With water, stores, spare parts, and donkey-boiler, as above, to be 400 tons.

Speed and Coal Endurance.—With 3500 I. H. P. a speed of 14 knots should be obtained under measured mile trial conditions, in perfectly smooth water, at the load displacement of 4018 tons. With 1300 I. H. P. a speed of 10 knots should be maintained at sea in fair weather, when 160 tons of coal will suffice for 1300 knots. With 300 tons of coal, about 2200 knots could be covered at 10 knots.

COST.

The estimated cost of hull and machinery is $1,750,000. With armament complete and the vessel ready for sea in all respects, the estimated cost is $2,200,000.

GUNBOAT.

This vessel has been designed to satisfy the following conditions: To be of such dimensions as to make good use of the inland-coast navigation system and work in shallow rivers and bays, to which end the draught may not exceed 7 feet when deep loaded. To be very handy and especially designed for bow attack. To carry one medium-power 10-inch B. L. R. gun, mounted forward on the line of keel, on a port-pivoted slide carried by two bulkheads thoroughly worked into the hull of the vessel; also four 57-mm. R. F. guns, mounted at points of vantage and with direct ahead fire, and one 37-mm. revolver in a military top.

The water-line in wake of boilers, engines, and magazines to be partially protected from machine-gun fire by a thick strake above the water-tight deck, the thick strake terminating forward in a thick bulkhead enclosing the gun-pit. Besides which, the coal is to be so distributed as to obtain the maximum protection from it both above and below the water-line.

The gun and gunners to be protected from ahead by a thick curved shield about 2 inches thick. The side-plating above the coal bunkers to be thickened in wake of the R. F. gun-ports.

A water-tight steel deck to be worked below the water-line, with sloping sides outboard from the stem to the forward engine-room bulkheads, beyond which the side-slopes will be continued to the after engine-room bulkhead.

To have twin-screws, large rudder area, and steering gear protected as far as possible.

To have a maximum smooth-water speed of not less than 10 knots, under standard conditions of measured mile trial with forced draft.

To carry coal enough at load displacement for 1000 miles, steaming at 8 knots, with bunker capacity for a larger supply.

PRINCIPAL DIMENSIONS.

The vessel designed to meet these conditions has the following principal dimensions: Length over all, 109 feet 3 inches; length between perpendiculars, 105 feet; beam, extreme, 27 feet 6 inches; draught, mean and extreme, 6 feet 6 inches; displacement in tons, 300; maximum I. H. P., 350; maximum speed in knots, 10.

ARMAMENT.

One medium-power 10-inch* B. L. R., to be mounted forward in the line of keel, carried on bulkheads thoroughly worked into the vessel's hull. To have a maximum elevation of 10° and depression of 2°, a gun-pit being recessed to the level of the water-tight deck to contain the slide, elevating press, etc.; the gun to be elevated and served by hydraulic pressure. Four 6-pounder R. F. guns are mounted two on each side in such a manner that all may be fired in a line with the keel forward, and the two after guns aft. One 37-mm. revolver to be carried in military top.

HULL PROTECTION.

A thin submerged water-tight deck to extend from the bow aft to the forward engine-room, and in the wings in wake of the engine-rooms. Longitudinal wing bulkheads to include a water-tight wing space for the stowage of coal, subdivided by the water-tight deck and transverse bulkheads. The coal stowage is continued above the main deck in trunks running from the after quick-firing gun to the 10-inch gun-shield, in wake of which the boxes are stowed with the bower chains. The fighting steering-gear is in a pit on the water-tight deck, amidships, wheel and helmsman being thus afforded some coal protection from machine-gun fire.

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* This gun to be 302 inches long and weigh about 23 tons. The charge of brown powder to be 175 pounds, and weight of projectile 430 pounds. Estimated muzzle velocity, 1875 f. s., with corresponding penetration at muzzle of 18¾ inches of wrought iron.

MOTIVE POWER.

To develop 350 I. H. P. under forced draft.

Boilers.—Two in number, of locomotive type, placed one on each side of the vessel in separate compartments, each served by its own stack, and a fan to be placed in each fire-room, worked by a shaft led through a casing from the fan-engines in the forward engine-room. Each boiler to be 3 feet 3 inches diameter of barrel, 9 feet long over the smoke-box. Grate surface of both, 18.4 square feet, to supply steam of 130 pounds. A feed tank, containing about 35 gallons of fresh water, to be fitted in each engine-room.

Engines.—Of two-cylinder, horizontal, direct-acting type, driving twin screws, each engine in a separate compartment. The diameter of the cylinders to be 11 and 18¼ inches; stroke, 14 inches. Air and circulating pumps of each engine to be worked by an independent steam cylinder, and fitted to remove water from the vessel. A barrel condenser, with copper shell and tube plates about 18 inches in diameter and 5 feet long, to be fitted to each engine.

Screws.—To be three-bladed, of steel, with forged boss and plate blades keyed to boss. Diameter, 5′ 6″; mean pitch, 6′ 6″. Revolutions at maximum power, 195.

Weight of Machinery.—Total weight of propelling machinery as above not to exceed 26 tons.

SPEED AND COAL ENDURANCE.

With 350 I. H. P. a speed of 10 knots should be obtained in smooth water, at load displacement of 300 tons. At this speed 30 tons of coal should suffice for 48 hours' steaming, covering a distance of 480 miles. With 70 tons, the distance covered would be about 1000 knots.

With 150 I. H. P., which should be obtained without forced combustion, a speed of 8 knots should be obtained in smooth water.

At this speed, 30 tons of coal would suffice for 150 hours' steaming, covering a distance of 1200 knots.

With 70 tons, the distance covered at 8 knots would be about 2600 knots.

COST.

The estimated cost of hull and machinery is $110,000.

With armament complete and the ship ready in all respects, the cost should not exceed $200,000.

FIFTH TYPE. (RAM.)

A vessel has been designed to fulfill the following conditions:

To attack an enemy's buoyancy and stability in unarmored parts, primarily by the ram, and also by torpedo and rapid-firing gun.

To combine, on a draught of water not exceeding 18 feet, and a displacement of about 3000 tons, a maximum speed of not less than 20 knots, great handiness and sufficient endurance for coast defense, with a special bow adapted to use as a spur, bow torpedo-tubes, a small but fairly protected battery of rapid-firing guns, and as much protection as can be afforded with the weight remaining.

Machinery, and especially boilers, of novel type will be avoided, as certainty of action of the motive power is imperative.

PRINCIPAL DIMENSIONS.

The vessel designed to meet these conditions has the following principal dimensions:—Length between perpendiculars,* 296′; length over all, 314′; beam, extreme, 40′ 8″; draught, mean and extreme, 18′; depth from under side of keel to line of top of main deck beams continued across the superstructure, 23′ 9″; depth to top of beams of superstructure, 27′; freeboard forward and aft, 12′; freeboard amidships at side, 5′; freeboard amidships to superstructure deck, 8′; freeboard amidships to top of berthing, 12′; load displacement in tons, 3010; maximum I. H. P. 10,000; maximum speed in knots, 20¾.

HULL AND PROTECTION.

The hull to be constructed of mild steel of the same quality as for the other vessels, as described in the Report of the Board on Fortifications, p. 326. The deadwood is well cut away aft, and as much forward as the form of the bow will permit. The form of the midship-section is such that the greatest beam is about 15″ above the L. W. L., whence the side tumbles home with a sharp round to the main deck, which extends the whole length of the ship 5′ above the L. W. L. For a length of about 80 feet forward and aft a forecastle and poop of light construction shall extend with a freeboard of 12 feet, and between them a central trunk or superstructure about 12 feet wide—except in wake of engine-hatches, where it will be 26 feet wide—standing 3 feet above the main deck. A hammock-berthing 4 feet high above the superstructure deck continues the line of poop and forecastle. A light plate bulwark 30″ high shall be worked on the forecastle from about 20 feet abaft the stem. A double bottom, 40″ deep at the middle line, to be worked under the boilers, taking the form of a water-tight platform under the engines and magazines. Frames to be spaced about 36 inches apart with lightened plate floors. Except in double bottom, to consist of 7-inch Z bars. Longitudinal wing bulkheads to extend throughout the boiler and engine spaces.

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* After perpendicular through axis of rudder.

An armor deck shall extend from over the steering gear aft to the armored bulkhead 60 feet abaft the stem, and from 15 inches above the L. W. L. amidships to 4′ 6″ below at the sides at mid-length, rising to 4′ aft, and to about 3′ 6″ at the armored side forward, whence it dips gradually to the spur. The beams to this deck to be 9-inch channel-bars plated over on top with plating of 15 pounds on the flat and 20 pounds on the slopes, and beneath, between the wing bulkheads, with a splinter-jacket of 10 pounds tapped to the flanges. The protective plating to be worked above the upper plating in a single thickness of 1⅛″ on the middle portion, and 3½″ on each of the two slopes of different inclinations forming each side. The inclination of the outer slope to the horizontal is 30° and of the inner 18°, while the middle portion is built to a round-up necessary to bring it 15″ above the L. W. L. at the middle line. The heavy plating to be without curvature.

Fore and aft carlings to be worked in wake of each knuckle of the deck and along the lines of hatches, in short pieces between the beams, to which they are connected with corner clips and lozenge-straps at the lower flanges. These carlings to be omitted outboard in wake of the longitudinal wing bulkheads, which will be made to support the first knuckle.

The beams to be joined to the frames with deep plate gussets, and the strake of bottom plating next below the deck shall be heavier than elsewhere.

Glacis plates 2 inches thick, at 30° inclination to the horizontal, to be worked to all the main hatches in the armor deck; to be also fitted with shell-proof gratings.

Coal to be stowed over the armor deck from the side to the trunk superstructure over the length occupied by the boilers, patent fuel being desirable for the wing bunkers. In the wings above this deck over the engines to around the stern, special water-excluding material will be used.

For a length of 60 feet abaft the stem, protection will be afforded by side armor of 4 inches with 3-inch backing on ½-inch plating stiffened by the common Z-frame, the armor extending from 5 feet above the L. W. L. to the line of armor deck, which will be constructed in this part with ordinary round-up and of 1-inch plating. A similar deck 1 inch thick to be worked on the line of the main deck above the armor. The lower plates of the side next the spur to be 1½″ thick and without backing.

The armor deck to join the side armor at an armored bulkhead 6″ thick with 3″ backing on ½″ plating below the line of armor deck, and a 3″ bulkhead above it to the 1″ plating of the main deck.

The stem to be a single steel casting from the main deck to its heel below the spur. The point of the spur to be a square of 6″ side with diagonal vertical, with a tempered steel cap secured to the casting. The side corners of the square to run into a side ram consisting of the lower piece of armor deck, tapering in thickness from 3″ at the stem back to the ordinary thickness of 1 inch. The bottom plating below the side ram to be 1″ to ¾″ thick for 12 feet abaft the point of the spur. The framing and bottom plating of the bow for a length of about 25 feet to be of extra heavy construction.

A conning tower to be carried on the forecastle, built with semicircular front of 6 feet diameter, with 4-feet straight sides, 8″ thick, and a rear plate of 3″, crown and base plate 1″ thick. To be entered in rear by a tube 30″ inside diameter and 2½″ thick, forming the lower part of the forward military mast. Weight complete about 20 tons.

PROPELLING MACHINERY.

To develop 6000 I. H. P. with open fire-rooms, and not less than 10,000 I. H. P. under forced draft, when burning good coal under standard conditions of smooth-water trial.

Boilers.—The main boilers to be four in number, of double-ended cylindrical pattern, making steam of 160 pounds. Diameter, 14′;

length, 19′ 2″. Grate surface of 24 furnaces, 530 sq. ft. Heating surface about 17,000 sq. ft. Weight of four boilers complete with water, all mountings, uptakes, stacks, and fire-room appliances, 462 tons.

The boilers to be in two compartments with four athwartships fire-rooms. Athwartships bunkers to extend across the ship at each fire-room to the wing bulkheads. The end bunkers to be four feet thick, and the one between the boiler compartments 6 feet. Each pair of boilers to be served by a stack standing at least 50 feet above the upper grates.

The boilers to be specially strapped and chocked for ramming. Fan-power to be supplied capable of maintaining an air pressure of 2 inches of water in the fire-rooms.

A donkey boiler with 15 sq. ft. of grate, and weighing, complete with water and all mountings and appliances, about 13 tons, to be located in the trunk superstructure above the armor deck.

Engines.—Four sets of vertical triple-expansion engines, two sets driving each screw, to be in four separate compartments, the forward sets arranged to disconnect in ordinary cruising. The engines to be specially braced for ramming.

Each engine to have three cylinders 25¼″, 37″, and 56″ diameter, with a stroke of 32″. The valve gears to be arranged so that a mean effective pressure of 40 pounds per sq. in., reduced to the area of low-pressure piston, may be obtained with a boiler pressure of 160 pounds, developing 2500 I. H. P. at 157½ revolutions per minute at a maximum speed of ship slightly exceeding 20¾ knots.

The weight of engines, condensers, and pumps, with water, shafting, and screws complete, will not exceed 360 tons.

Screws.— To be of steel or suitable composition, four-bladed, 12′ 6″ diameter, with uniform pitch of 15′ 7½″, and developed area of blades of each screw of 35½ sq. ft. Equivalent screws of other pattern may be substituted, having due regard to efficiency in backing.

The total weight of propelling machinery, with donkey boiler and stores in limited quantity, will not exceed 850 tons.

ARMAMENT.

The battery will consist of:

1. Seven 36-pounder rapid-firing guns with 1100 rounds, four mounted on the forecastle and three on the poop.

2. Four 3-pounder rapid-firing guns with 1200 rounds, mounted

one in the bow and one in the stern above the main deck, and two on the trunk superstructure.

3. Three Maxim 10 mm. guns with 7500 rounds, mounted two on the forward and one on the after military masts.

The guns to be fitted with heavy shields of considerable area.

Torpedoes.—Two fixed torpedo tubes to be fitted side by side in a fore and aft line in the bow through the 4-inch armor below the main deck. The tubes to be placed well back, so that the openings in the armor may be closed with shutters having little projection. Six torpedoes to be carried with all necessary machinery.

Note.—These protected bow torpedo tubes are fitted in the belief that in a vessel having the speed, handiness, and protection of a ram, it will often be desirable to use the torpedo, when it can be done with reasonable certainty, instead of the ram when the speed and direction of the exposed enemy may render ramming dangerous, however strong the bow of the ram within the practical possibilities of such a finely formed ship.

The total weight of armament as above, with all accessories and equipment, will not exceed 85 tons.

SPEED AND COAL ENDURANCE.

With 10,000 I. H. P., a speed slightly exceeding 20¾ knots should be obtained under smooth-water trial conditions at the load displacement of 3010 tons. At this speed 170 tons of coal will carry the ship about 250 knots.

Steaming with two boilers and open fire-rooms, 2700 I. H. P. should be maintained continuously, with a corresponding speed of 15¼ knots, when 170 tons of coal will carry the ship about 850 knots.

A speed of 10 knots can be attained in smooth water with 615 I. H. P., when 170 tons of coal will carry the ship about 2500 knots.

While 170 tons is the normal coal supply sufficient for the ordinary work of the vessel, it is intended to carry 300 tons on leaving port ordinarily. The total bunker capacity of the ship is about 550 tons, and this amount may be taken on without risk in undertaking an extended voyage, with a corresponding steaming distance of about 7500 knots at 10 knots.

MANŒUVRING POWER.

The vessel to have a partially balanced sternway rudder of about 150 sq. ft. area, worked by power capable of moving it from hard over to hard over at full speed in at least 15 seconds.

At a speed of 19 to 20 knots, a complete circle should be turned in 2¾ minutes, with a tactical diameter of about 1000 feet.

SUMMARY OF WEIGHTS.

	Tons.	Per cent Displacement.
Hull proper, with all fittings and auxiliaries	1,170	39.0
Armament	85	2.75
Machinery	850	28.20
Protection, including conning tower and water-excluding material	595	19.75
Equipment, boats, stores, people, etc.	140	4.65
Normal coal supply	170	5.65
Total load displacement	3,010	100.00

COST.

The estimated cost of hull and machinery is $1,250,000, and of the vessel complete and ready for sea $1,375,000.

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

COLLISIONS AT SEA.

(LES ABORDAGES EN MER.)*

BUREAU OF NAVIGATION, NAVY DEPARTMENT,
WASHINGTON, D. C.

In view of the interest felt by maritime nations on the subject of collisions at sea, and the means proposed for the prevention of these disasters, the President of the United States has issued invitations for an International Congress, to be held at Washington during the coming autumn, which will consider the subject of the revision of the existing regulations.

By direction of the Bordeaux Geographical Society, and also at the request of the Geographical Society of Lisbon, Lieutenant M. A. Hautreux, of the French Navy, assisted by Captain Lannéluc, a seaman of long experience in the merchant service, drew up a series of proposed changes, for consideration by the Congress, in which they have endeavored to simplify the present rules.

By permission of M. Hautreux, I have translated the pamphlet containing the result of their labors, and hope that it will prove of service.

CHAS. M. MCCARTENEY, *Lieutenant, U. S. N.*,
Division of Sailing Directions.

HYDROGRAPHIC OFFICE, WASHINGTON, D. C.,
February 28, 1889.

A Congress is to meet at Washington on October 1, 1888, in order to study the different questions having regard to the safety of vessels at sea. This Congress will have an international character, and will formulate rules that should be adopted by all maritime nations.

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*By M. A. Hautreux, Lieutenant de vaisseau en retraite, Membre de la Société de Géographie Commerciale de Bordeaux. Translated by Chas. M. McCarteney, Lieutenant, U. S. N.

The subject of collisions at sea is one of the principal questions to be considered by this Congress. The Geographical Society of Bordeaux having been invited by Commandant Riondel to take hold of this question, had already anticipated the application of the Commandant, with a view to revising the regulations concerning the rules established to avoid collisions.

The Geographical Society of Lisbon addressed a note to us proposing a study of these diverse questions. The Bordeaux Society concluded that, in the presence of the movement which has been brought about with a view to the revision of these regulations, it would cause a study to be made of these questions, and transmit the result of these studies to the Congress at Washington. Captain Lannéluc, commanding a vessel in the foreign trade, and Lieutenant Hautreux, of the French Navy, were charged with this duty, and we herewith present the result of their labors.

COLLISIONS AT SEA.

The international regulations, designed to prevent collisions at sea, were codified in 1862. Since that time important modifications have been made in the dimensions and the speed of vessels, as also in their modes of lighting; and studies have been pursued in order to augment the power and compass of sound signals.

During the twenty-five years since these rules have applied, numerous disasters have demonstrated that the sailing vessel was a danger as considerable to the steamer as this latter was to another vessel of its own class. The lighting of the former is absolutely insufficient, and its sound apparatus (fog horn) during a fog has a compass decidedly too feeble.

With the actual speed of steamers, the colored (side) lights, designed to show the course of the vessel, have not sufficient power to give the desired security; the green light does not show far enough, and the red, in a mist or fog, does not differ enough from a white light.

The regulations themselves have a vicious feature in subordinating the manœuvring of the steamer to that of the sailing vessel, and furthermore in the calculation as to the tack or sailing point of the latter* (Arts. 14 and 17). One can find fault with their complication when it is known that they must be applied not only by captains, but by seamen acting as officers, many of whom offer as a guarantee experience totally inadequate. The number of these articles is not less than ten. Article 14 contains five paragraphs.

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* See Note B.

It appears that these regulations could be modified so as to interpose new elements of security, and we propose the following :

GENERAL REGULATIONS.

Article 1.—Every vessel, whether steamer or sailing vessel, shall carry, from sunset to sunrise, a white light at the foremast head, and two side lights, green to starboard and red to port.

The lights of steamers shall be *electric* lights. Steamers whose speed exceeds twelve knots must have their electric lights *scintillating*. Steamers whose speed does not exceed twelve knots must have their electric lights *fixed*. Sailing vessels must have their white light placed at the fore-topmast cross-trees. Fishing vessels not required to carry permanent lights shall be obliged to show a lantern or a torch, with frequent occultations.

Article 2.—Steamers under way to carry forward a second electric light, placed so as to make an angle of 45° from the vertical with the masthead light, which will be lighted only in case of meeting another vessel.

Article 3.—During a fog, the sound (fog) signals that will be made use of shall be operated by compressed air, and placed at the masthead with parabolic, turning reflectors.

In order to distinguish them from the fog signals established on shore, the signals on board ship must be made on the roll.

Steamers to make use of the most powerful horns.

Sailing vessels to make use of shrill whistles.

Fishing vessels to use a small hand trumpet (cornet à bouquin).

RULES OF THE ROAD.

Article 1.—Every vessel that perceives another must take a bearing immediately ; if the bearing does not change, there is risk of collision.

Article 2.—Whenever a vessel bears less than two points from another's course on either bow, and there is danger of collision, she changes to starboard (ports her helm) until the danger has been cleared.

Article 3.—Whenever a vessel bears *more* than two points on the bow, and there is danger of collision, *that one of the two* which has the other to *starboard* is responsible, and shall yield the right of way, moderate her speed, and stop or alter her course until she has changed the bearing sufficiently to clear her.

Article 4.—Whenever a vessel perceives another, and it is necessary to manœuvre to avoid her, she must operate her sound signals and fire a rocket to indicate her intention (to manœuvre).

Article 5.—A vessel that has been stopped, or is unable from any cause to manœuvre, will indicate the fact by frequent occultations of her masthead light.

Article 6.—During a fog, vessels must operate their sound signals (fog signals) every *five* minutes at least, and oftener when in frequented localities.

If a vessel hears another's signal, moderation of her speed and even stopping is *obligatory* until the signal has been recognized and located.

SPECIAL REGULATIONS.

Article 1.—For the navigation of steamers that proceed alongshore from headland to headland, those vessels having the land on the starboard hand will keep it at a distance of not more than 5 miles. Vessels having the land on the port hand will keep off at a distance of not less than 10 miles.

Article 2.—In narrow channels, in entering ports, roadsteads, or rivers, vessels should always keep to the right of the channel.

Article 3.—Vessels at anchor in frequented places will carry forward two white lanterns placed close together, and one underneath the other.

Article 4.—On all vessels carrying passengers, the officers keeping watch must be licensed for long voyages or for coasting vessels.

Article 5.—On every vessel making either long voyages or coasting trips, the watch officers must possess certificates of fitness.

Article 6.—Suits for damages resulting from collisions between natives and foreigners will be adjudged by a tribunal composed of a local magistrate, assisted by two consuls of standing, whose nationalities, as far as possible, shall be other than those of the litigants.

The regulations proposed depend upon the following considerations:

GENERAL REGULATIONS.

Article 1.—It is evident that the farther away a vessel is seen, the less chance there will be of collision. It is, therefore, necessary that the vessel be provided with the most powerful lights, having the greatest range attainable with the resources and internal arrangements of each ship.

The electric light, having a power of illumination much greater than that of oil lamps, should be preferred above all wherever it can be installed; and this can easily be done on all vessels having engines. It can be decided, therefore, that for the masthead and side lights of steamers this will be obligatory.

Passenger steamers generally have a greater speed than simple cargo boats. It would be well, then, to distinguish between their lights by a mechanical arrangement of simple and easy execution.

In the case of sailing vessels, they can be lighted only by oil lamps. In order that the light should have a great range (visibility), it should be placed as high as possible, and in order that it should have the greatest power it should be *white*. It is necessary, therefore, that the light used to signal the vessel should be *white* and placed on the mast.

The present regulations do not permit the sailing vessel to signal herself from a distance by this means; it seems that the main object was to distinguish between the steamer and the sailing vessel. It is certainly important to recognize the nature of the obstacle, that we may meet it; but it is, above all, important to perceive it as far off as possible; and, as steamers can be readily distinguished from sailing vessels by their electric lights, it seems possible to increase the visibility of the sailing vessel by requiring it to carry a white light at its foremast head. In order to avoid the chance that this light may be obscured by the head sails, it should be placed under the topmast cross-trees; it would not interfere with the bracing of the topsail, and could not be concealed by the foot of the topgallant sail.

In order to distinguish fishing vessels, and all other vessels that cannot easily get out of the way, from those possessing complete control over their movements, it would seem that the method of occultations (flashes), very easily made on all vessels, will readily give a precise indication of the situation.

Article 2.—The course on which the vessel sighted is following is a very important element to estimate; the red and green side lights, actually in use, would suffice for this purpose if one could recognize them at a sufficient distance; unfortunately, the coloration is an obstacle to long range; further, on sailing vessels these lights are often not placed high enough, and it frequently happens that they are obscured by the spray of the sea. The green and the red are, maybe, not the best colors to use in order to have sufficient range. For steamers, thanks to the facilities offered by electricity, we would be able to return again to the idea of M. Prompt, Lieutenant de vaisseau, Commandant aux Messageries Maritimes. This officer proposed to place a second white light forward* of the masthead light, forming with this light an angle of 45° with the vertical. This light would be illuminated only in case of encountering another vessel; it would be visible only forward of the beam. We see at once that the angular position of the two lights with the vertical would constitute a very valuable indication of the course, and be visible a very long distance, since this second light would also be a white, electric light.

The angle of the two lights would be maximum, that is to say, 45°, whenever one were directly on the beam of the vessel carrying them. It would be nothing (0°), the one light above the other, whenever the vessel carrying them was exactly end on to us. The second light to the *left* of the first would indicate that we see the *port* side of the vessel; the same light to the *right* of the masthead light would indicate that we see the *starboard* side of the vessel perceived. With some experience, the approximate angle of the course of the two vessels could be estimated quickly. Such a light, reserved to steamers, and actuated by electricity, could be placed on one of the fore-stays above the head of the jibs.

Article 3.—In time of fog, the sound signals will be operated by compressed air.

It is no more difficult to use compressed air on a steamer than to use steam; the use of the latter is subject to great inconvenience by reason of the condensation in the leading pipes, obstructions or choking of the pulley, and the feebleness of the sound at the beginning.

With respect to the sailing vessel, the actual operation of the trumpet, produced by means of the human breath, is of little importance and has no great range or capacity. It is not difficult to compress the air by a hand pump within reach of the lookout on the bow, and then to use the steamer's whistle on board of the sailing vessel, while the steamers make use of powerful horns.

The hand-trumpet should remain in reserve for fishing vessels. In order to distinguish during a mist or a fog, the *vessel's* signals from those made *on shore*, the former should be made always on the roll.

The experiments that have been made on the propagation of sound during a fog have shown that the greatest advantage for the capacity of the instrument (sound emitter) is gained by placing it as high up as possible, and that the sound should be projected in the direction determined upon by means of reflectors. These reflectors should have a mechanism of rotation, and project the sound successively in all directions about the vessel.

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* See Note C.

The variations of intensity of the sound would aid powerfully in recognizing the true direction, and, perhaps, also the distance of the signal heard.

RULES OF THE ROAD.

Article 1.—The obligation to take a bearing of every vessel as soon as she is sighted, and to enter the bearing in the log, would be an important element of consideration in case of encountering.

Article 2.—Without entering into a long discussion of the possibilities that lead to a collision, there are some intersecting courses that are more dangerous than others. The bearing, which is the means of knowing if there is danger of collision, requires several successive observations, and a certain interval between each observation; this method is the better, the greater the distance between the vessels and the greater the angle between their paths. But, when the angle between the vessels' courses is acute, the method becomes the less reliable as the speed of the vessels is great, and as—the vessels standing nearly end on to each other—the time required to estimate the danger is the more limited. It seems that the requirements of Article 15* of the existing regulations, instead of being restricted, as they are, by the decree of 1884, might be extended so as to include a sector of two points, for instance, on each bow.

A very simple geometrical construction shows that, in the case of an encounter at equal speed, the angle of the bearing (the angle formed by each track and the line of bearing between the two vessels) is equal to one-half of the angle at the crossing of the two tracks.† Therefore this article should apply even if the angle of crossing of the two tracks amounts to 90°.

For a steamer, the space necessary in order that it may change its direction two points is, in general, equal to once and a half its length—that is, one hundred and fifty meters (164 yards) for a vessel of one hundred meters (328 feet), the diameter of whose turning circle is six hundred meters (656 yards).

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* See Note D.

† See Note E.

The rule indicated to come to starboard would be dangerous only if the vessel perceived was discovered to be two points on the starboard bow, and at a distance less than twice the length of the vessel. We will admit that, at that distance, if there is danger of colliding and if there is any hesitation in acting, the collision would not be avoided.

Article 3.—When the angle of the bearing is more than two points, the angle of the crossing of the two tracks is less acute. If there is danger of collision at a distance of equal visibility, the point of intersection is farther away, the distance and the time in which to manœuvre are much greater. It seems that, in requiring one of the two vessels (that one which sees the other to starboard) to manœuvre, and, in all circumstances, to yield the right of way, the law is as clearly applicable to the sailing vessel as to the steamer. Consequently, if it is a sailing vessel that sees another vessel to starboard, and there is danger of collision, and if she is, moreover, close-hauled on the starboard tack, she will luff, deaden her headway immediately, and the other vessel will stand across her bows. Should it be a steamer in the same situation, she will moderate her speed, stop if necessary, if the distances are closing, and she will obtain the same result. If the vessel sighted is to *port*, in order that there be danger of collision it is necessary that she present her starboard side; it is *she* then that will have to manœuvre, and if she makes an error she will be responsible for accidents.

Article 4.—It seems entirely desirable that, whenever two vessels are in danger of encountering each other, they should mutually make call and distinguishing signals: the sound signals first, then a detonating signal (rocket ?), in order to indicate the commencement of the manœuvre to follow.

Article 5.—We propose to indicate the inability of broken-down vessels, as well as fishing vessels, to manœuvre also by frequent flashes of the masthead light. This means, easy of execution, would not be confounded with any other, and would be perceptible as far as the range of the light itself.

Article 6 explains itself. We believe that, with the variations of sound produced by the revolving parabolic reflectors, the situation of the vessel will be more readily estimated.

GENERAL REGULATIONS.

If it were possible to determine, for each voyage, a route to go and another to return, the chances of collision would be greatly diminished. But a similar project, applicable only to steamers, and which does not prohibit the crossing of the routes, has raised so many objections that it appears to be abandoned. Notwithstanding, there are localities, like those of the Banks of Newfoundland, for instance, where we find a great number of vessels assembled unable to manœuvre, and for whom it is desirable to enforce some special conservative (protective) measures.

Article 1.—It should be adopted partly for the navigation of the steamer that runs along the coast from headland to headland.

Article 2.—It should be the same for the entrance into harbors, roadsteads and rivers.

Article 3.—The regulations for the lights of vessels at anchor should be modified by using *two* lanterns (stay lights) forward, very close together. The distance apart (to the eye) of these lanterns would indicate the vessel's proximity, and would not be apt to be confounded with the gas lamps or any other lights on the shore.

Article 4.—We believe that the regulations should *require* from all persons called, even momentarily, to take charge of the vessel, guarantees of technical instruction and ability that would give that security which it is only right to exact for the passengers and cargo. This obligation is all the more necessary where the vessel carries passengers or emigrants. It is by hundreds that we count the human beings who confide in the professional ability of those who have charge of the vessel. A knowledge of the rules of the road should constitute part of the qualifications exacted of candidates for positions on foreign-going or coast-wise vessels. The duties of the officer of the watch, by night as well as by day, are filled by seamen of whom no legal guarantee is exacted. There are certainly careful seamen, keeping a faithful watch, but it is as certain that a great number among them have an incomplete knowledge of the rules of the road established to avoid collisions. A certificate of ability is required in the naval service to fulfill the duties of the seaman and petty officer, and there should be no difficulty in exacting an analogous guarantee of every seaman seeking service as watch officer on a merchant vessel.

Article 6.—Finally, it seems that the courts, which adjudge all cases of damages between vessels of different nationalities, should have, to a certain degree, an international character, always reserving the presidency of said court to the local magistrate within whose jurisdiction the action for damage is brought.

APPENDIX.

RULES OF THE ROAD.

The rules of the road that we propose are comprised in the following two articles:

A.—Whenever a vessel bears from another *less than two points on the bow*, if there is risk of collision, she comes to starboard (ports) until she has cleared the danger.

B.—Whenever a vessel bears from another *more than two points on the bow*, if there is risk of collision, *that one of the two vessels* which sees the *other to starboard* is responsible for the manœuvre. She should yield the right of way, moderate her speed, stop or change her course until she has changed the bearing on her bow sufficiently to clear the danger.

Whenever a vessel sees another, in order that there should be danger of collision, it is necessary:

1. That the course of each of the vessels should cross the bows of the other, or that they should be directly opposed to each other.

2. That the speeds of both vessels should have a certain relation to the angle of intersection of the courses.

The first condition can be filled when, to *starboard*, we perceive the *port* side of another vessel; when, to port, we perceive the starboard side of another vessel, or when, *right ahead*, we see the masts of another vessel in line.

The second condition is filled when the angle of the bearing of the vessel sighted does not vary.

These two conditions can be established only when the visibility is sufficiently great that one may with certainty recognize some details of the vessel.

The *visibility* is, then, the first of all the conditions to fill in order to avoid collisions. Also, we propose that by night, every vessel, sailing vessel or steamer, should be required to carry at an elevated point on the mast one or more white lights of the greatest illuminating power possible.

The visibility being obtained, the *angle of bearing* can be taken; but whatever surety is given by this means, several observations, and a certain interval of time between them, are necessary in order to derive any advantage from them.

Now, according to the clearness of the atmosphere, and when the angle of the intersection of the vessel's course is acute, this method may be unreliable, or at least give place to indecision—the most dangerous thing to happen in case of vessels meeting. It is completed by the knowledge of the course of the vessel sighted.

This intelligence is given during the night by the side lights, green or red. These lights have a feeble power—above all, the green. It is nevertheless the sole means that the sailing vessel possesses to designate (signal) her from a distance.

This is why we propose that the sailing vessel should have a white masthead light, and that the steamer should have a second one on the forestays. This disposition would double the distance of visibility of the sailing vessel, and, for the steamer, would make her course known at double the actual distance.

It is, above all, in the intersection of courses at an acute angle—the most dangerous of all—that the second white light of the steamers would have its special use.

For, suppose that to *starboard*, at an angle of 10°, 15°, or 20° with the course, we see the *lower* white light to the *right* of the masthead light, there is not any danger of a collision, and the officer of the watch is well convinced of it before seeing the green light of the steamer; but if he sees the lower light to the *left* of the masthead light, he knows immediately that there is danger considerably before seeing the *red* light, and, if the bearing confirms the danger, the rule imposes upon him the duty of coming to starboard (porting).

In the conditions of lighting that we propose it cannot be dangerous for the vessel to come to starboard (porting), unless the obscurity of the atmosphere was such that the white lights would not have been visible at a distance of 200 meters (about 220 yards). In this case it would be a fog, and the sound (fog) signals, which are audible at 1000 meters (nearly 1100 yards), would have been put in action, and would have preserved the two vessels from danger of collision.

With regard to the sailing vessel, which is actually signaled only by her colored lights, we know that the sudden appearance of a green light to port, or of a red light to starboard, is a just cause of apprehension for the officer of the watch, and that, according to the time he takes, the distance may be so shortened that all manœuvring becomes useless. We must remember that a steamer, forging ahead at a speed of 16 or 17 knots, cannot be stopped in a short space, and that even a simple change of direction requires a certain distance. This is why we earnestly advocate, besides the side lights, green and red, a white masthead light for the sailing vessel and a second white light (of direction) for the steamer.

These general regulations admitted, we should call attention to the complications of Rule 14, which contains not less than five different paragraphs, and which base the manœuvre (to be made by the sailing vessel) upon the course and sailing point of the vessel that she has just seen approaching, and having nothing but a colored light to guide her in estimating this point.

How can one judge with precision if this vessel is sailing close-hauled or running free? The greatest indecision reigns in the mind of the officer who does not always accurately remember these five paragraphs.

We think that in generalizing Article 16 and applying it to *all* vessels, steamers or sailing vessels, we enact a simple rule which will not escape the memory of the seaman.

The facility for making changes of speed and direction is often greater on board of a sailing vessel than on a steamer; it seems that to-day there should no longer be an accumulation of all the responsibilities upon the steamer, and that the sailing vessel may share them. We may assert that the greater number of cases of collision result from indecision in the manœuvre of the one or the other of the vessels, and, sometimes, of both at once. It seems to us that, in specifying that in all cases the vessel which perceives another to starboard will be responsible for the manœuvre, that sole responsibility will suffice to indicate to the seaman the manœuvre to make, and we think that in all doubtful cases he should yield the right of way.

This rule, of attributing the responsibility to one of the two vessels, has of itself the advantage of diminishing the chances of indecision by half, because all the vessels that are seen to port either are indifferent because their courses cannot lead to a collision, or if they *do* offer this danger, it is only when they present the starboard side to the first vessel; they are, then, the ones responsible for the manœuvre, and should yield the right of way.

There cannot be any question of a vessel changing her course for all vessels that she sees to starboard, but only whenever there is risk of collision and this risk is made apparent by the bearing. We have said that the bearing does not give this intelligence with sufficient rapidity whenever the angle of the courses is acute. It is for this reason that we propose to extend the provision of the 15th Article of the existing regulations so as to include an angle of 22°30′ (or *two* *points*) on each bow, and that we say to come to starboard (port the helm) until the danger be cleared. It is above all in the case of limited visibility, at the time when the officer of the watch is absorbed by the danger of collision, that we believe we do a very serviceable act in giving him an absolute rule, which, combined with the responsibility limited to one of the vessels, cannot lead to any hesitation.

The rule that we indicate can only be dangerous if the risk of collision is recognized at less than 200 meters (about 220 yards) distant. In that case there would be fog, in which event the vessels would have sounded their fog signals and be proceeding with caution. But if one has not kept a careful watch, if he has not proceeded with caution, all the rules possible will be defective, and the collision will take place or will not take place according as the tracks lead towards it or deviate from it.

We hope that, with the addition of a second white light on the steamer, and a white light for the sailing vessel, the distances of visibility will be doubled, and that the time which the vessels have for manœuvring will also be doubled.

The distance of visibility would then be actually *doubled* for the sailing vessel—that is, four miles in clear weather, or more than seven kilometers, but the knowledge of her course would be known for only two miles, because of the feeble visibility of the colored lights.

DISCUSSION OF THE RULES OF THE ROAD.

If in the sector of 2 points to the *left* of the course one sees the *red* light of another vessel, the courses diverge; there is no manœuvre.

If, in the sector to the *right*, one perceives the *green* light of another vessel, the courses diverge; there is no manœuvre.

But if, in the sector to the *left*, one sees the *green* light, or if, in the sector to the *right*, one sees the *red* light, the courses converge, and, if the bearing does not change, there is a risk of collision.

We say that the two vessels should come to starboard.

First Hypothesis.—Suppose the vessel A sees the *green* light of the vessel B to *port* at less than 22°30′ (2 points) from her course. As he has already seen B's *white* light for some time, he has taken a bearing and knows that the course is dangerous and that he will have to come to starboard.

On his side, the vessel B necessarily sees A to starboard. He knows then that he is responsible for the manœuvre, and that, if there is danger of collision, he will have to give way. Three cases present themselves: 1. A may have a less speed than B; 2. a speed equal to that of B; or 3. a greater speed than B.

1. A having a *less* speed than B. A very simple construction shows that A bears from B at a smaller angle than B bears from A; consequently, the manœuvre of B is doubly indicated. He sees A in the dangerous sector to starboard; he (B) comes to starboard (ports).

2. A having a speed equal to that of B, A bears from B at the same angle that B does from A, consequently B still sees A in the dangerous sector to starboard; he (B) comes to starboard (ports).

3. A having a greater speed than B, A may then bear from B at an angle greater than the two points of the dangerous sector. The first rule does not apply, but the second rule compels him to yield the right of way and to pass under the stern of A.

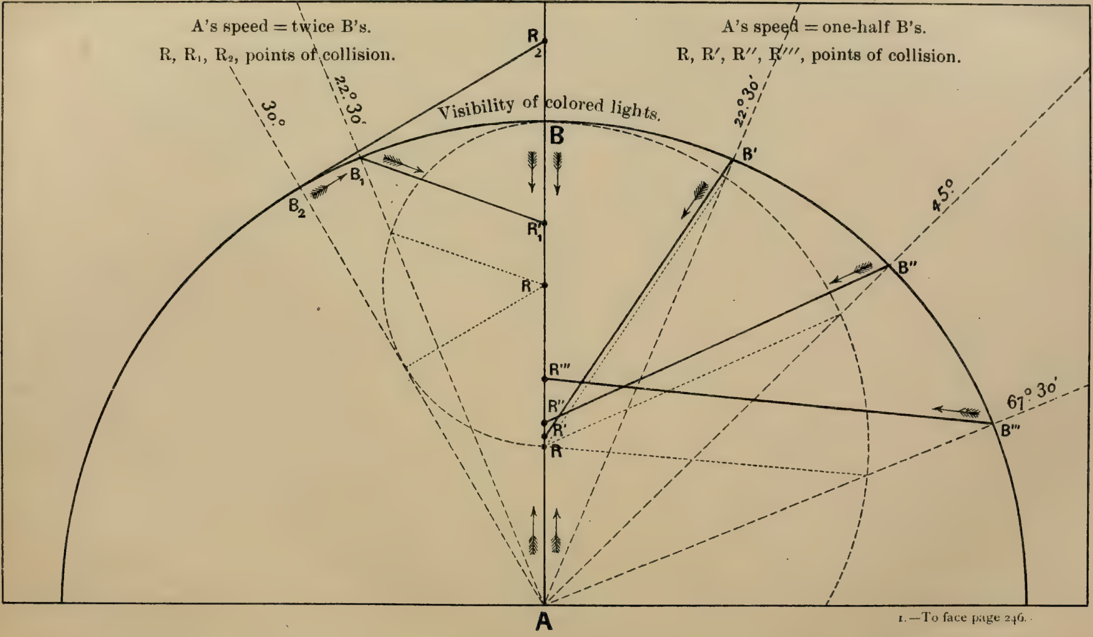
We see that in these three cases there can be no indecision for A or for B, because B, who sees A to starboard, will always manœuvre so as to pass under his (A's) stern.

Second Hypothesis.—If the vessel A sees the vessel B's *red* light to starboard at less than two points from his course, having seen the white light, he knows his course is dangerous and leads to a collision. A will, without hesitation, come to starboard, pass under B's stern, and will thus avoid collision.

The speed that B may have with regard to A is here a matter of indifference, because, in all cases, it is A that should manœuvre, as he is responsible.

But A may be a steamer or a sailing vessel. If A is a steamer, he will find no difficulty in coming to starboard, and for the extreme change of direction of 22° 30′ (two points), it is only necessary that he shall have, at most, a clear space ahead of him of 200 meters (about 220 yards).

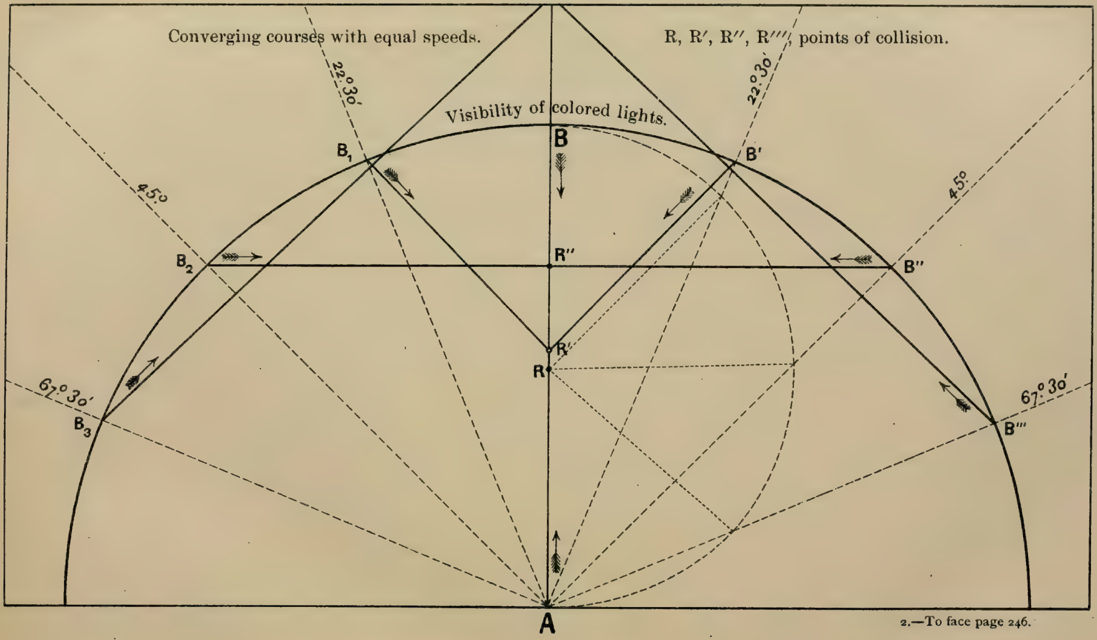
If A is a sailing vessel, and he should be close-hauled on the starboard tack, he cannot readily come to starboard, but by flowing his head-sheets, by backing a sail, he will modify and diminish his speed; in consequence, B, who has A to port, will see that the bearing changes, drawing aft, and he will not have any hesitation in coming to starboard, which he will always be able to do even if he is a sailing vessel, because, in the case where A is close-hauled (on the starboard tack), B would have the wind free, or aft. If B found himself close-hauled on the starboard tack, when he has been sighted by A, in coming to starboard, he will diminish his speed, but, in this case, A would be on the port tack, with the wind abeam at least, and as he is



A's speed = twice B's.
R, R₁, R₂, points of collision.

A's speed = one-half B's.
R, R′, R″, R‴, points of collision.

1.—To face page 246.


Converging courses with equal speeds.
R, R′, R″, R‴, points of collision.
Visibility of colored lights.
22°30′
22°30′
45°
45°
67°30′
67°30′
B
B₁
B₂
B₃
B′
B″
B‴
R″
R′
R
A

2.—To face page 246.

responsible for the manœuvre, he would bear away, according to the rule, and pass under B's stern.

There is no difficulty, then, in carrying out the provisions of this rule in any case between steamers, or between steamers and sailing vessels, or between sailing vessels; but its importance is decidedly manifest between steamers moving at high rates of speed. For speeds of 18 knots, the rate at which two vessels would approach each other is such that a kilometer (nearly 1100 yards) is traversed in less than a minute. It is under such circumstances that it is necessary that the officer should have a rule so precise that there would be no room for hesitation or loss of time.

Finally, there is still the case of absolute calm for the sailing vessel, and of disabled machinery for the steamer, which renders both incapable of action.

Article 5 then applies, and this state of disability is signaled by frequent occultations (flashes) of the white light.

We think that the signal of sighting, which is not actually obligatory, should become so, and that the sound signal should be made in the limit of visibility of the colored lights; this limit is, at the same time, that of the estimation of the direction, and of the necessity for manœuvring. It is in this last case, and at the moment when a vessel changes her course, or modifies her speed, that she should apprise the vessel in sight by firing a rocket.

The two accompanying plans are explanatory of the cases where the vessels A and B are supposed to have equal or different speeds.

Outside of the sector of 22° 30′ (two points) on each bow, that we call the dangerous sector, for an equal distance of visibility, the distances of encountering augment rapidly, and, consequently, the time permitted for reflection and for manœuvring. The greater the angle made by the intersecting courses, the more sensible are the changes of bearing, and the calculation of the danger of collision made almost immediately. We think that for seamen the clause of the responsibility attached to one of the vessels, joined to the obligation to yield the right of way, is sufficient to indicate in all cases the manœuvre to make. This rule has a great practical range, and renders useless the multiplication of rules that surcharge the memory and give rise to the greatest hesitation.

It is in view of this simplification that we demand that all persons performing the functions of officers on board ship should be supplied with certificates, stating their perfect knowledge of the rules of the road.

In these notes that we submit to the Congress of Washington we do not pretend to solve all the difficulties that pertain to the question of collisions. We have wished to call attention to the necessity of a better method of signaling the sailing vessel, to simplify the rules of the road, and to exact a certificate of ability from every person desiring to be charged with the conduct of a vessel.

NOTES.

NOTE A.—This Congress was to have been held at Washington, in April, 1889, but, owing to the action of Great Britain, it was indefinitely postponed. Great Britain having accepted, it has finally been decided to hold the Congress during the coming autumn.

An Act providing for an international marine conference to secure greater safety for life and property at sea.

Be it enacted by the Senate and House of Representatives of the United States of America, in Congress assembled, That the President of the United States be, and he hereby is authorized and requested to invite the Government of each maritime nation to send delegates to a marine conference that shall assemble at such time and place as he may designate, and to appoint seven delegates, two of whom shall be officers of the United States Navy and one an official of the Life Saving Service, two masters from the merchant marine (one from the sailing marine and one from the steam marine), and two citizens familiar with shipping and admiralty practice, to represent the United States at said marine conference, and to fill vacancies in their number.

Sec. 2. That it shall be the object of said marine conference to revise and amend the rules, regulations, and practice concerning vessels at sea, and navigation generally, and the "International Code of Flag and Night Signals"; to adopt a uniform system of marine signals, or other means of plainly indicating the direction in which vessels are moving in fog, mist, falling snow, and thick weather, and at night; to compare and discuss the various systems employed for the saving of life and property from shipwreck, for reporting, marking and removing dangerous wrecks or obstructions to navigation, for designating vessels, for conveying to mariners and persons interested in shipping warnings of approaching storms, of dangers to navigation, of changes in lights, buoys and other day and night marks, and other important information; and to formulate and submit for ratification to the Governments of all maritime nations proper international regulations for the prevention of collisions and other avoidable marine disasters.

Sec. 3. That the sum of twenty thousand dollars, or so much thereof as shall be necessary, is hereby appropriated, out of any money in the Treasury of the United States not otherwise appropriated, for the necessary expenses of said marine conference, including the pay and allowances of the representatives of the United States therein, which shall be at the rate of five thousand dollars per annum, and actual necessary expenses for such delegates as are not salaried officers of the United States, and the latter shall be allowed their actual necessary expenses. The Secretary of the Navy is hereby authorized to provide the conference with such facilities as may be deemed necessary. The powers and authority conferred by this Act upon the persons appointed by the President by force thereof shall terminate on the first day of January, Anno Domini eighteen hundred and ninety, or sooner, at the discretion of the President.

Sec. 4. That it shall be the duty of the Secretary of State to transmit to Congress a detailed statement of the expenditures which may have been incurred under the provisions of this Act.

Approved July 9, 1888.

NOTE B.—STEERING AND SAILING RULES.

SAILING VESSELS.

Art. 14.—When two sailing ships are approaching one another so as to involve risk of collision, one of them shall keep out of the way of the other, as follows, namely:

(a) A ship which is running free shall keep out of the way of a ship which is close-hauled.

(b) A ship which is close-hauled on the port tack shall keep out of the way of a ship which is close-hauled on the starboard tack.

(c) When both are running free, with the wind on different sides, the ship which has the wind on the port side shall keep out of the way of the other.

(d) When both are running free, with the wind on the same side, the ship which is to windward shall keep out of the way of the ship which is to leeward.

(e) A ship which has the wind aft shall keep out of the way of the other ship.

STEAMSHIPS TO KEEP OUT OF THE WAY OF SAILING VESSELS.

Art. 17.—If two *ships*, one of which is a *sailing ship* and the other a *steamship*, are proceeding in such directions as to involve risk of collision, the *steamship* shall keep out of the way of the *sailing ship*.

NOTE C.—This idea of the second white light forward, placed at an angle with the vertical, was advanced by Lieut. F. F. Fletcher, U. S. Navy, whose article on the subject, written some three years ago, was discussed in the Proceedings of the U. S. Naval Institute.

This idea is based upon the American system of central range lights, the practicability of which for sea-going vessels was first demonstrated in No. 39 of the Proceedings of the U. S. Naval Institute, December, 1886.

According to this system the colored side lights are abolished, and all vessels will carry two range lights forward and one stern light aft. The range lights forward are visible from ahead to two points abaft each beam, and the stern light is visible from aft to two points forward of each beam. The two range lights are carried in a vertical plane parallel to the direction of the keel, with the lower light so placed forward of the upper light that an imaginary line drawn through these two lights will make an angle of 55° with the vertical.

With this arrangement of lights the inventor claims that the direction in which a vessel is heading is known at a glance, and every change in her heading or in your position on her bow is at once made apparent. This is more easily and more accurately determined at night by means of these lights than can be done during the day by noting the appearance of the ship's masts and hull. It will be seen that when you are right ahead of a vessel, her two range lights will appear in a vertical line, one directly above the other. If you are one point on a vessel's bow, her lights will appear inclined one point from the vertical. If you are two points on her bow, her lights will appear inclined two points from the vertical. At three points on her bow the inclination of her lights will be three points from the vertical, and at four points it will be four points, or 45°. When you are more than four points on her bow, her lights will be inclined more than 45°, and at six points on her bow, her stern light becomes visible. Between two points forward of her beam and two points abaft her beam all three of her lights will be visible. Abaft this, her stern light only will be visible. It was demonstrated that any error due to the heeling or rolling of the vessel is immaterial.

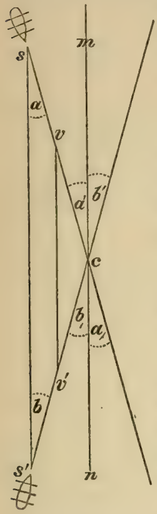
In experiments made to determine the practicability of this system, numerous observations were made by different observers, and it was found that the greatest single error in estimating the heading of the ship was less than one point, while the average error was but little more than one quarter of a point. It is claimed that these lights can be readily placed upon all classes of vessels, whether steamer or sailing vessels, at no more expense than the placing of the present lights, and fulfill all the conditions required.

Owing to the fact that vessels differ so greatly in their speed, it is apparent that the knowledge of a vessel's approximate speed becomes almost as important a factor as a knowledge of your position on her bow. To indicate the approximate speed of all vessels, and to make the distinction between a steamer and a sailing vessel, the following was proposed:

All steamers having a speed of thirteen knots or more will carry two bright white range lights as above described, and one of these lights will be so fitted with a screen that it will be mechanically occultated every one-half minute. Steamers whose speed is less than thirteen knots will carry the white range lights without the occultating speed signal. Sailing vessels will carry the range lights placed as on steamers, the upper one being white and the lower one red. We shall thus know whether a steamer's speed is approximately fifteen knots or approximately nine or ten, which distinction is considered close enough for all practical purposes. A sailing vessel will have the advantage of carrying a bright white light which may be seen at a long distance, and the color of her lower range light will distinguish her from a steamer.

NOTE D.—STEAM VESSELS MEETING.

Art. 15.—If two ships under steam are meeting end on, or nearly end on, so as to involve risk of collision, each shall alter her course to starboard, so that each may pass on the port side of the other. This article only applies to cases where ships are meeting end on, or nearly end on, in such a manner as to involve risk of collision, and does not apply to two ships which must, if both keep on their respective courses, pass clear of each other. The only cases to which it does apply are when each of the two ships is end on, or nearly end on, to the other; in other words, to cases in which by day each ship sees the masts of the other in a line, or nearly in a line, with her own, and by night to cases in which each ship is in such a position as to see both the side lights of the other. It does not apply by day to cases in which a ship sees another ahead crossing her own course, or by night to cases where the red light of one ship is opposed to the red light of the other, or where the green light of one ship is opposed to the green light of the other, or where a red light without a green light, or a green light without a red light, is seen ahead, or where both green and red lights are seen anywhere but ahead.



Note E.—A very simple geometrical construction shows, that in the case of an encounter at equal speed—(supposing, of course, two vessels to be equally distant from the point of collision)—half the angle $\left(\frac{a'+b'}{2}\right)$ at the crossing (of the two tracks) is equal to the angle (a or b) formed by each track and the line of bearing (between the two vessels).

Draw mn parallel to ss', then $a=a'$ and $b=b'$. As $a=b$, so must $a'+b'=2a=2b$; hence either one, a or b, is half the angle between the crossing tracks. This holds good—always supposing a movement at equal speed—when the vessels approach nearer and nearer the crossing point, as at v and v'.

Therefore this article should find application even if the angle of crossing (of the two tracks) amounts to 90°.

DISCUSSION.

Lieutenant McCARTENEY.—The frequency with which collisions at sea have occurred of late years, and the disastrous consequences resulting from them, have made it apparent that some change must be made in the existing regulations, which must be made as plain and as simple as possible, and a rigid enforcement of the rules be exacted. The International Marine Conference has been called for this purpose, and the foregoing paper of M. Hautreux presents some very desirable features for its consideration.

The benefit to be derived from the white mast-head light of the sailing vessel, thereby increasing her range of visibility from two to five miles, is apparent at once, while the addition of the second white light forward, for the steamer, not only distinguishes her at once, but possesses the very material advantage of signaling her course long before the colored side lights, with their feeble power, can be seen. When we consider the high rate of speed of modern steamers, and the short space of time in which they traverse the distance between the visibilities of the colored and mast-head lights, the importance of this knowledge is obvious.

Without entering upon a repetition of what has been said by the authors, if the distance at which a vessel can be seen and her course known is doubled, chances of collision are lessened immensely: there is double the time to act, and the danger resulting from indecision is removed. The range of visibility of the steamer can be still further increased by the use of the electric light, and as the necessary plant can be readily placed on board this class of vessels, and requires little extra attention, there should be no difficulty in its adoption. So much for the lighting.

In regard to the proposed change in the rules governing the manœuvring of the vessels, they can, no doubt, be much simplified, and especially Art. 14, with its five attendant clauses; but that the rule giving the sailing vessel the right of way in all circumstances should be changed to one placing her on an equality with the steamer, is, I think, questionable. While it might operate with fair success in ordinary weather, in a calm the sailing vessel is practically helpless, while in very heavy weather, any attempt at luffing, or changing the course, might be attended with disastrous consequences to the sailing vessel. The motive power of the steamer being so completely under control, it seems that there should be no question between the two. With the mast-head light proposed for the sailing vessel, even if the steamer is moving at a high rate of speed, the element of danger in the handling of the latter is removed by more than doubling the time allowed to change the course or stop the engines. The recommendation of the employment of different routes for eastward and westward-bound vessels is not the least important of the suggestions made, but the difficulty has been to have these recommendations followed, each captain being naturally desirous of shortening his voyage as much as possible.

There can be no doubt how greatly the adoption of a route to go and another to return will conduce to safety. With these routes, varying with the seasons, and sufficiently separated to avoid the possible danger of a vessel which is following one, from drifting into the other, from not having had observations for two or three days, the chances of collision will be much lessened. The U. S. Hydrographic Office, in its monthly publication of the Pilot Chart, has for a long time earnestly advocated this subject, and each month calls special attention to the best transatlantic steamship routes.

In his annual report to the Bureau of Navigation, the Hydrographer says: "Every effort has been made to collect the latest and most reliable data concerning ice in the vicinity of the Grand Banks, but very few reports have been made of this great danger south of the parallel of 45° N. The transatlantic routes, as laid down on the Pilot Chart, seem to have been adopted by the Boston steamship lines more generally this year than ever before, which accounts in part for the scarcity of ice reports. Many captains have been inclined to regard the recommendations as unnecessarily cautious, but such illustrations as the collision of the Geiser and Thingvalla affords have convinced the most skeptical of their value. The routes of the various transatlantic steam lines are slowly, but surely, drawing together, and while in all probability they will not reach the extreme limit for ice-season travel recommended by the Chart, they will approximate to it, and the adoption of one path each way for all will be a great improvement." An objection raised to the Pilot Chart routes by Captain Banaré, of the French Hydrographic Office, is that they are not widely enough separated, thus giving opportunity for the possible error previously mentioned, due from lack of observations, wild steering, etc.; but this is a very minor point, and could be easily remedied when certain fixed limits have been adopted and vessels rigidly required to observe them.

In the second part of "Les Collisions en Mer," recently published in the Annales Hydrographiques, Captain Banaré says that "in giving to navigators a regulation that offers a guarantee of security, the tendency would be to diminish the watchfulness on board ship by raising a feeling of false confidence on the part of the captain, from the certainty which he would have that all vessels moving in the contrary direction would follow the official route; also that the lengthening of one of the routes, which would be the natural consequence of the adoption of the double track, could be another element of danger, inasmuch as all vessels would then maintain an exaggerated speed not only in foggy weather, but at all times, so that the number of collisions, instead of diminishing, would be considerably increased." It is hardly probable that, should such routes be adopted, a captain would take upon himself the responsibility of leaving his proper track, knowing that in case of collision he or his company would be held responsible for the loss of life and property incurred. Still less would this be apt to occur in thick weather.

Perhaps the most important feature of the paper is that relating to fog signals; much time and attention has been devoted to this subject for years by maritime nations. M. Hautreux recommends that steamers make use of the most powerful horns, and sailing vessels of shrill whistles; also, that these be placed as high up as possible, and the sounds be directed by means of reflectors. The importance of knowing the class of vessels encountered is evident, and here is another reason why the sailing vessel should continue to have the right of way.

In the current (April) number of the North American Review appears an interesting paper, giving the views of several prominent captains of trans-atlantic vessels on the subject of fog signals at sea. A summing up of their views would indicate: 1st, the necessity of the adoption of a system of fog signals; 2d, that whatever system be adopted, it should be so plain and simple that it could be instantly understood—the fewer and simpler the signals, the better; 3d, powerful steam whistles, of uniform size and tone, to be subjected to a government test; 4th, a fixed maximum rate of speed, which vessels must not exceed during a fog, and that on hearing each other's whistle they be required to stop until the signals are understood; 5th, that the intervals between successive blasts should not exceed one minute.

In Article 6 of his Rules of the Road, M. Hautreux says: "During a fog, vessels must operate their fog signals every *five* minutes at least, and oftener in frequented localities." This interval is too great, considering the high rate of speed of modern vessels, and although he says "oftener in frequented localities," there should be a fixed interval, which should not be exceeded in any locality; nothing should be left to chance. An example mentioned in the Review, by Captain Boyer, shows the necessity of this: "Supposing two steamers to be approaching each other with great speed, it is necessary that they should hear each other's signals before the distance separating them becomes too small to permit manœuvring. If each is going at the rate of 20 knots, a maximum speed on the high seas at present, the two vessels approach each other at the rate of 40 knots an hour, or $\frac{66}{100}$ of a knot per minute. It appears to me indispensable that the respective whistles be heard at least *six* minutes before the ships meet; hence it is necessary that the whistles should carry the sound $\frac{66}{100} \times 6 = \frac{396}{100} =$ to about four nautical miles."

In regard to the signals to be used, nearly all agree as to their character and necessity—the long, powerful blast of the whistle to indicate the vessel's proximity, and, as suggested by Captain Kennedy, late of the Germanic, a separate or peculiar blast to indicate eastward or westward-bound vessels, to be followed by the compass signals, not to exceed 8, one for each four points of the compass. With such a code and prompt action, collisions would be rendered impossible. Somewhat similar to Captain Kennedy's suggestion is a system of course signals proposed by Mr. Frank Hamilton, of the Bureau of Navigation, in September, 1888, as follows:

PROPOSED AMENDMENT TO THE REVISED INTERNATIONAL REGULATIONS FOR PREVENTING COLLISIONS AT SEA.

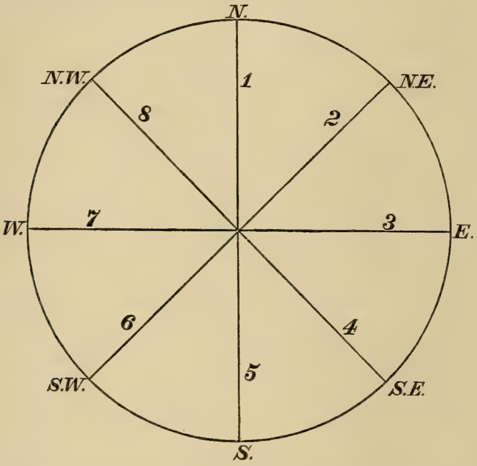
Approved by the Congress of the United States, March 3, 1885.

Article 12. Strike out paragraphs marked (*a*) and (*b*), and insert in their place the following, viz.:

"(*a*) A steamship under way shall make with her steam whistle or other steam sound signal, and a sailing ship under way shall make with her fog horn, at intervals of not more than two minutes, the number of blasts indicating the nearest point to the course she is steering, according to the following code, viz.: one (1) blast for north; two (2) blasts for northeast; three (3) blasts for east; four (4) blasts for southeast; five (5) blasts for south; six (6) blasts for southwest; seven (7) blasts for west; and eight (8) blasts for northwest.

"(*b*) Upon knowledge of the proximity of another ship, every ship shall steer as nearly as practicable the exact course she indicates, until it becomes necessary to alter her course to avoid collision, in accordance with Article 14 to 23 inclusive, or until the danger of collision is past."

Article 19 of the Regulations is hereby repealed.



Another system of proposed general fog signals to indicate the course steered is that which is known as the "Bureau Plan," but the combination was arranged by Mr. L. Waldecker, of the Navy Department. It is based on the well-known fire alarm system, so familiar to every one. It met with considerable favor by the maritime nations to whom it was submitted, including, I understand, the English Board of Trade; but, later on, the Admiralty claimed that it interfered with their Channel system of sound signals. Should England approve this plan, I believe that other nations have signified their willingness to adopt it.

Both these plans, that of Mr. Hamilton and that of Mr. Waldecker, will be submitted to the International Congress.

WASHINGTON, D. C.

Lieutenant-Commander B. F. TILLEY.—The proposed Rules of the Road are remarkably simple, and I admit that simplicity is desirable in framing rules which are to have such universal applications as these; but in the endeavor to simplify matters we should not fail to be explicit in stating exactly what is required of each of two vessels that are approaching each other so as to involve risk of collision. By the proposed rule "B," the vessel that sees the other to starboard is responsible for the manœuvre, but nothing is said in the Rules about the other vessel's keeping her course. In the Steering and Sailing Rules now in use we have the following:

"Art. 18. Where, by the above rules, one of two ships is to keep out of the way, the other shall keep her course, subject to the qualifications contained in the following article:

"Art. 19. In obeying and construing these rules, due regard must be had to all dangers of navigation, and due regard must also be had to any special circumstances which may exist in any particular case rendering a departure from the above rules necessary in order to avoid immediate danger."

In the new international rules of the road at sea, I think it would be advisable to have a rule containing the provision of Article 18, given above, and it might be well to increase its force by changing the word *shall* to *must*, so that the new rule shall read: The vessel not responsible for the manœuvre *must* keep her course, subject to the qualifications of Article 19. I regard this rule as necessary, because I have known several cases of steamships crossing where a collision would have occurred if in the manœuvre where one ship was required to keep out of the way of the other, the other ship had changed her course. Without such a rule it would be inferred that the vessel not responsible for the manœuvre was to keep her course, but the matter is too important to leave to inference.

There are some few cases that may arise when vessels are crossing where it seems necessary that the vessel which sees the other to port should be required to manœuvre to avoid collision. Take the following dangerous situation of two vessels, which might be brought about by the failure or accidental extinguishing of running lights: The first, a long, fast steamer, suddenly discovers another vessel to starboard, in such close proximity that she, on account of her great headway, cannot avoid passing ahead of the vessel sighted, thereby unavoidably exposing herself to the danger of being run into on the starboard beam. She must go ahead, and cannot avoid a collision. All she can do is to reduce the effect of the collision by sheering with the helm. Suppose that the vessel sighted is a heavily laden coal schooner, running with a strong, free wind. Now, it may be in the power of the schooner to avoid the collision altogether, and she should be obliged by some imperative rule to make every effort to do this. It appears to me that the proposed rule "B," which in a case like the above would put all the responsibility on the helpless steamer, might make the other vessel careless in looking out for and avoiding a danger that in this instance would come from the port side. The great number of coal schooners running along our coast makes the situation of two vessels as described above a very possible one, and if a collision should occur under the supposed conditions, it is likely that both vessels would be sunk.

NAVAL ACADEMY, ANNAPOLIS, MD.

Ensign HAYDEN.—The portion of the essay to which I wish to refer is the following, printed under the heading "General Regulations":

"If it were possible to determine for each voyage a route to go and another to return, the chances of collision would be greatly diminished. But a similar project, applicable only to steamers, and which does not prohibit the crossing of the routes, has raised so many objections that it appears to be abandoned. Notwithstanding, there are localities like those of the Banks of Newfoundland, for instance, where we find a great number of vessels assembled unable to manœuvre, and for whom it is desirable to enforce some special conservative (protective) measures."

This question of the best regulation of steam traffic across the Grand Banks seems to be one of the most important as well as difficult problems that can come before the Marine Conference, and I am inclined to doubt whether this or any other conference will be able to agree upon and enforce any set of regulations that will improve, to any appreciable extent, the present status of affairs. Nevertheless, it should be thoroughly considered from every point of view, and an international tribunal is the only one that can properly do so. Moreover, the results of the deliberations of the Conference in other directions—its decisions as to lights, fog signals, and rules of the road—have such an important bearing upon this question that its consideration may best be taken up after other points have been definitely decided.

From my connection with the publication of the Pilot Chart, I have of necessity considered this subject very carefully, and perhaps on that account more fully appreciate the difficulties in the way of the adoption and enforcement of any hard-and-fast regulations or restrictions regarding transatlantic steam navigation. So many things enter as factors in the problem, and with such constantly varying force, that I must deprecate the hasty adoption of any of the specious and plausible schemes that look so well on paper and yet would never work in practice.

"The longer any one studies a vast subject," says Professor Bryce, in The American Commonwealth, "the more cautious in inference does he become." The world-renowned Maury even proposed a plan of "lane-routes," and although it has still a prominent existence on paper, yet it has not now, and really never did have, any particular force in practice.

With the Pilot Chart for December, 1887, there was published a brief discussion of this subject, and certain routes were recommended. The plan thus initiated has been adhered to since that date, so far as recommendations go, and a brief résumé may therefore be of interest.

Eastward Bound.—Follow this track, or nothing to the northward of it: Leaving New York, steer for latitude 40° 26′ N., longitude 73° 46′ W., thence ESE. ½ E. to the 100-fathom line, then deep soundings, and off soundings, crossing 60° W. in 42° N. and 50° W. in 45° N.; thence follow the great circle, crossing 40° W. in 48° 01′ N., 30° W. in 49° 56′ N., 20° W. in 50° 55′ N., and 10° W. in 51° N.

Westward Bound.—Follow this track, or nothing to the southward of it: Cross 10° W. in 51° 10′ N.; thence following the great circle, crossing 20′ W.

in 51° 16′ N., 30° W. in 50° 28′ N., 40° W. in 48° 46′ N., and 50° W. in 46° N. Cross 60° W. in 43° N., 69° W. in 40° 38′ N.; then keep inside 30 fathoms, steering to cross 74° W. in 40° 30′ N.

With the addition of a route from the English Channel (course about west by north), joining the west-bound route in about long. 20° W., and the shifting of both routes to the southward during the ice season, this plan has been consistently and persistently recommended on the Pilot Chart, and many letters of approval have been received from practical navigators and others. The main feature of this plan is, it will be noticed, to *keep to the right* of a narrow central belt whose limits are accurately defined, both graphically and by means of a detailed printed description. Westward-bound vessels are thus enabled to take advantage of the Labrador current, shaving Cape Race, if they choose, and eastward-bound vessels can go as far south as they please, to take advantage of the Gulf Stream and the easterly drift-current in mid-ocean. At the same time, in the central belt the danger to the fishing fleet and other vessels is at a minimum; to the north of this belt, danger is to be looked for principally from the *east*, and to the south of it, from the *west*.

Neglecting the fact that different ports of departure and arrival must always interfere with this or any other plan, I may refer to certain other difficulties that may or may not prove insuperable. In the first place, there is the self-evident truth that this great highway of steam navigation, the connecting link between the old world and the new, is of vast and steadily increasing importance. Even now, although it is traversed yearly at almost railway speed by vessels intrusted with more than a million human lives and property of an aggregate value of fully a billion dollars, the inventive genius of the age is devoting its best energies toward meeting the demand for better, larger, faster, and safer vessels. The steamship that breaks the record, and carries the pennant for the best passage, becomes famous, and her success is heralded to the four corners of the earth. Now, this fact indicates "a condition, not a theory"; it means that there is a *demand* that must be considered and complied with, and regulations that lose sight of or attempt to discountenance it are as absurd as would be an attempt to regulate, by statute, the speed of railroad trains.

Again, general averages regarding the limits of ice off the Grand Banks are often of no earthly use so far as any particular season is concerned; the present season, for instance, has been a marked exception, almost no ice at all having been reported. The usual or normal limit of drifting ice cannot, therefore, be considered, and we must base our routes upon the conditions that actually exist, as reported by incoming vessels or by telegraph from St. Johns. Another important element is the fact that the mails are given to the fastest vessels. One steamer may take a safer route, traverse a slightly longer distance, and lose the mail: this very thing happened only last year, when the Werra was beaten a few hours by the Servia, and Captain Bussius complained that he had followed the route recommended and lost the mail in consequence. This question should therefore be carefully considered, and postal regulations framed accordingly.

Last, but by no means least, all possible reasonable precautions should be taken to avoid unnecessary danger to the brave fishermen who follow their hazardous occupation on the Grand Banks and adjacent fishing grounds, constantly exposed, in their little sailing vessels, to all the dangers of this stormy coast, and surrounded half the time by dense fog that gives them scant notice of the approach of one of the rushing ocean greyhounds whose sharp bow would cut them through like a knife. In this connection let me quote from Captain J. W. Collins, of the U. S. Commission of Fish and Fisheries, whose long experience and intimate acquaintance with all the circumstances of the case render his opinion of great value. Captain Collins says, in a letter dated Washington, April 12, 1889: "So far as any plan is concerned to secure the safety of fishermen upon the Banks by the recommendation of definite lines of travel for ocean steamers, I give as my opinion that it would add much to the safety of fishermen if lines could be established during the greater part of the year which would take the steamers south of the Grand Banks. From March to November there is a large fleet fishing upon the Grand Bank, aggregating somewhere from 500 to 700 vessels, belonging to the United States, British North American Provinces, France, and Portugal. A comparatively small number of vessels, principally from the United States, fish upon the Grand Bank throughout the year. The fishing grounds extend from about 42° 57′ north latitude, which is practically the southern limit for halibut, to the northern margin of the Bank, and sometimes even beyond it. I appreciate the obstacles which might be met with in an attempt to prohibit steamships from crossing the Grand Bank, since I realize the force of your statement that the Banks cannot be 'fenced in.' I think, however, that, considering the danger incident to the crossing of the Banks in the spring, summer, and autumn, when fogs are prevalent, it would be vastly to the advantage of the fishermen, and an act of humanity, if the steamship lines could be arranged to pass south of the Grand Bank from March to November. In winter, the vessels fishing upon the Grand Bank are generally collected about its southern extremity, where they go to fish for halibut. I would say that at that season the danger to fishing vessels would not be so great, if steamers are to cross the Grand Bank anyhow, if the crossing were made north of the 44th parallel of north latitude, or about where it is limited on the chart you have sent me. A very slight deflection, to avoid the southern point of Banquereau, would take the ships clear of all fishing grounds resorted to west of the Grand Bank, and would carry them far enough north so that they would not come in contact with the majority of the fleet, at that time fishing on the latter bank. I have drawn in, roughly, lines which I would suggest for spring, summer, and autumn travel, from March to November, so arranged that the northernmost would just clear the southern prong of the Grand Bank. I most earnestly hope that the steamship companies may be disposed to adopt some system which will relieve the fishermen from the perils now encountered by them in consequence of transatlantic steamers crossing the Banks. It seems that this might be done without material disadvantage, for the presence of ice enforces the deflection I have suggested for a part of the year, and there would only remain a comparatively short time when the transatlantic trade would have to diverge from the courses heretofore followed in late summer and autumn."

These considerations seem to me to be the principal ones that have an important bearing on the question, and serve to illustrate its complexity and the difficulty of a practical solution that will be advantageous all around. Evidently, conflicting interests must be considered, and a compromise effected, or else the whole thing left *in statu quo*. When we consider, however, the enormous importance of transatlantic steam navigation; the demand for great speed and quick passages; the fact that the shortest route is close to Cape Race; that storms, fog, and ocean currents enter as a factor less and less every year; that a single great ocean steamship, carrying the transatlantic mail and straining every nerve to lessen the gap that separates the old world from the new, represents almost, if not quite, as great a value, in number of lives and amount of property, as the entire fishing fleet of every nationality;—considering all these things, I must say it seems to me that all other interests are necessarily subordinate, and any regulations likely to be effective must be framed accordingly.

WASHINGTON, D. C.

Lieutenant F. F. FLETCHER.—The principle involved in these propositions is that of placing a bright white light on all sea-going vessels, by means of which they are enabled to be seen at a great distance. Having this great range of visibility, it is claimed that two or more successive bearings may be taken to determine if the vessels are approaching a point of collision. If we could always see a vessel's light at a sufficient distance, and then rely upon the accuracy of the subsequent bearings, it would seem that this method might answer the purpose. If we depend upon this method of avoiding collision, a single white light on each vessel is all that would be required, since the colored side lights perform no part in the method pursued. They would simply act as a convenience, by telling us whether or not it would be necessary to take bearings, and even then this information comes at a time long after we are supposed to have taken at least one bearing. Beyond this tardy but conveniently useless information, they would be of no use in carrying out the method of avoiding collision here proposed.

By means of the present white mast-head light of steamers, the method of taking successive bearings to avoid collision has been in use for some years, and experience has taught that it is inadequate to the purpose. This method is successful when the vessel is seen at a sufficient distance. But some means is required by which we can avoid a vessel that has, for many reasons which exist at sea, approached to a distance within which collision may easily be avoided, when there is no time to take doubtful successive bearings. For this purpose the one needful point of information required is how many points you are on the bow of that vessel. The placing of a second white range light forward of the mast-head light on steamers can convey this information, and it will be found in practice that it will seldom be necessary to resort to successive bearings. Attention is called to the fact that by slightly increasing the angle of inclination beyond 45°, the efficiency of the range lights will be much greater.

The white light proposed for sailing ships, although an undoubted improvement, will place them in no better condition than the present unsatisfactory condition of steamships.

When a steamship is to avoid a sailing ship, it is just as necessary for her to know how that sailing ship is heading as if the latter were another steamship. Thus, suppose that a sailing ship is three or four points on the bow of a steamship, and that the steamship is only about a point on the bow of the sailing ship. If the steamship could see this, it would be evident to her that there would be no possibility of collision in keeping her course; but not knowing this condition, and not having time for successive bearings, she would, under the law, stop and attempt to go astern—that is, pursue the only course that could lead to a collision. The propositions under discussion leave this most common case of collision unprovided for.

In regard to the proposition to extend the rule of port helm to two points on each bow: before pointing out the serious defect of its practical application, I would call attention to a few facts connected with the manœuvring power of steamships. The Office of Naval Intelligence has recently taken measures to collect information on this subject from a number of captains now in command of steamships, many of whom kindly performed experiments at sea for this purpose. It is found that a steamship with fair manœuvring power and a speed of 12 knots will travel 480 yards from the time the helm is put over until she clears a spot that bore two points on her bow. Under certain conditions to which the proposed rule would apply, two such vessels will collide if they both put their helm to port when at a distance of 740 yards. If one of these vessels concludes there is no danger of collision, and decides to keep her course, while the other one, being in doubt, decides to comply with the rule laid down, collision can take place at a distance of 1230 yards from the point where the helm was put over. With vessels of 18 or 20 knots speed, or less manœuvring power, it will be seen that these distances within which collision may take place, although conforming to the proposed rule, will be greatly increased.

As a question of manœuvring power alone, the table below will show the relative chances of collision between two 12-knot vessels under different actions of the helm between 300 yards and 1000 yards. These chances are calculated upon the supposition that their courses intersect, and either one bears within 30° on the bow of the other, which would probably be the practical condition under which the proposed rule would work.

	Chances of Collision.
When both vessels keep their course	301
When both vessels turn from each other	470
When both vessels turn towards each other	299
When one turns from the other	469
When one turns towards the other	121
When both port according to proposed rule	191

This table applies to the case of two vessels of equal speed, but by averaging the result of all classes of vessels it will not differ materially from the above.

It will be seen that it is about 35 per cent safer for one vessel to turn towards the other than for both vessels to port the helm according to the proposed rule. The reason for this lies in the fact that when the second vessel also puts her helm over, it throws her stern so far over towards the path of the first vessel that the effect, within 1000 yards, is not compensated for by her change of direction.

But the real danger to be apprehended from the proposed rule will be found in the extension of the limits within which it will practically be applied, and the uncertainty and hesitancy arising from doubt as to when it is applicable. By an examination of the testimony in cases of collision, it is seen that the natural tendency is to follow blindly any rule, regardless of the result. If this rule confines action within certain limits, these limits in practice will extend much beyond what is defined, and the rule will be applied in all cases of doubt, not to avoid collision, but to be on the safe side of the law.

The present regulations require steamships meeting end on or "nearly end on" to port the helm, and clauses were added explaining the construction of the article by which it would appear that the dividing line as to what course to pursue is made so clear that there could scarcely be a possibility of acting outside the limit so accurately defined. Yet in practice it is noticeable that when two vessels at sea are meeting "nearly end on," although quite clear of each other, one will often port the helm and cross the other's bow. Since these tendencies exist, they must be given due weight in formulating rules of the road. There can be no dividing line from which to determine our course of action more readily defined from the deck of a ship than that of right ahead. If, now, we change this dividing line to two points on each bow, we shall not only double the number of positions from which we must determine our course of action, but we shall make the limits within which the rule applies indefinite in practically defining them. It will be found in practice that vessels will put the helm to port much beyond the two-point limit, owing to the tendency to follow a fixed rule and be clear of responsibility. Such a condition would be a retrograde movement towards the old law of the port helm.

WASHINGTON, D. C.

Mr. L. H. TURNER.—Having received from Lieutenant H. P. McIntosh, in charge of San Francisco Branch Hydrographic Office, a pamphlet entitled "Advance Copy for Discussion," etc., I take pleasure in forwarding my opinions on the subjects therein discussed.

I am holder of Master's Certificate No. 6549, issued by the Shipmasters' Association of New York, for sailing vessels, and certificate No. 4050, issued by U. S. Inspectors of Steamships, District of California, as master of steam vessels, and have had 19 years' experience at sea, in all capacities. I have read with much interest the proposed rules for avoiding collisions at sea.

The proposal to permit sailing vessels to carry white mast-head lights meets my fullest approbation, and were it the *only* change made, would go far towards lessening the liability of collisions in all instances of clear weather. That the increase of the range of visibility is a decrease of the liability of collision, is a *very* self-evident truth needing no demonstration; therefore the adoption of the electric light to distinguish steamers is, in the present simplified and perfected state of the electric-light plant, certainly practicable and advisable.

I favor the system of range lights, as recommended by Lieutenant F. F. Fletcher, in preference to that of Lieutenant Hautreux. But in Lieutenant Fletcher's system he recommends that the lower range light of sailing vessels shall be *red.* Coloration shortens range of visibility, therefore I think steamers having a speed of thirteen knots and over should carry two electric range lights, the lower scintillating. Steamers with a speed under thirteen knots should carry two electric range lights, both fixed, and sailing vessels should carry two *white* range lights of *oil*, the difference between electric and oil lights being quite sufficient to distinguish sailing vessels from steamers.

Regarding Steering and Sailing Rules, I view with apprehension any attempt to change Article 14 (Note B), for I believe the rule most firmly grounded in the minds of our merchant seamen, both officers and sailors, is the very simple one, that vessels sailing on the wind on the starboard tack have invariably the right of way, and the other provisions of the same article I consider so thoroughly established as to make it in no small degree dangerous to change. I fear many lives lost would be the price paid for the change.

Article 17 (Note B) I think should also remain in force, for when the steamer alone is in *all* instances required to manœuvre, the responsibility is confined to one officer, and therefore the liability of error is reduced to a minimum; also, steamers, with their power of stopping and backing at will, are far more perfectly and easily controlled than sailing vessels.

Article 4, requiring passing vessels "to operate their sound signals and fire a rocket," I think superfluous. If in clear weather, it is entirely unnecessary, as the manœuvre would probably be commenced before the sound signals could be heard across the intervening distance, and the eye would give sufficient notice of each manœuvre; and if in fog, the sound signals required at that time by law would receive little or no assistance from the discharge of a rocket, which would tend to complicate the duties to be thought of and distract the attention of the officer in charge. I heartily approve of improved fog signal apparatus, the "fog horn" now used by sailing vessels being sadly deficient in power and range.

I do think that the Federal Government should require that *all* commanders and officers of watches should possess certificates of ability, to be obtained from duly accredited boards of examiners.

And, finally, I believe that regular steamship lines should be restrained by law from laying the course of their prescribed route across any bank or fishing ground where many fishing craft lay at anchor, when a slight détour would save the great annual loss of life occurring from collision. Especially should this be regulated by international law or agreement, regarding the fog-covered Banks of Newfoundland.

San Francisco, Cal.

Mr. JOHN CODMAN.—The suggestions of M. Hautreux, valuable as many of them are, do not tend to "simplify the present rules." An intelligent naval officer, or commander of a steamship of the regular lines, might easily comprehend and memorize them; but they would be apt to confuse the masters of many sailing vessels and "tramps." It would be better for all men to know a few rules of the road well, than for a few men only to understand many rules. I have often thought that a simple "whistle alphabet" might be contrived, after the principle of telegraphy, to indicate in a fog the direction in which a ship is steering. For all practical purposes, and with a regard to simplicity, eight variations should be sufficient. The notes of the horn in sailing vessels should have the same length and distance apart as those of the whistles of steamers.

NEW YORK.

Ensign WALTERS.—In accordance with the request of the Naval Institute, that I criticise the proposed changes in the Rules of the Road, I have the honor to submit the following:

General Regulations, p. 2, Art. 1. "Steamers whose speed exceeds twelve knots must have their electric lights scintillating." Art. 5, p. 3, Rules of the Road. "A vessel that has been stopped, or is unable from any cause to manœuvre, will indicate the fact by frequent occultations of her mast-head light." This might result in confusion between a vessel going over twelve knots and one not going at all.

Art. 2, p. 2. Steamers to carry a second light at an angle of 45°, to be lighted only upon encountering another vessel. If the other vessel perceives her first, the other will think it is a sailing vessel, or else a steamer whose second or lower light is not visible, because, though not expressly stated, it is given as the plan of M. Prompt (p. 4), that this light should not show abaft the beam. I think Lieutenant Fletcher's idea the better, and see no reason why both lights should not be kept going all the time.

The plan of Lieutenant Fletcher, to abolish side lights and substitute the central range, the lower light on sailing vessels to be red, and the angle of the two forward lights to be 55°, seems to me to be an excellent one, and the arrangement of having the two forward lights to show from ahead to two points abaft the beam, while the stern light shows from aft to two points forward of the beam, seems to me to meet the case exactly. In case of occultations of one of the forward lights being resorted to for the purpose of indicating a speed of over thirteen knots, it should be the lower one, which provision will allow occultations of the upper one to indicate that the vessel is stopped or disabled.

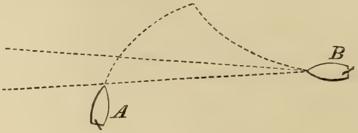
Art. 2, Rules of the Road, p. 3. This article is so ambiguous that I have been unable to discover its hidden meaning. Future references to this article seem to point to the fact that the pronoun "she" refers to the second vessel; but in the article it refers, from the construction of the sentence, to the first. This would involve collisions where there would be no danger of them if no change were made in the course of either vessel. It would be better to alter the sentence to read: "Whenever a vessel has another bearing less than two points on either bow, and there is danger of collision, the former ports her helm until the danger has been cleared."

Page 3, Special Regulations, Art. 1. It should be specified that those having the land on the starboard hand shall keep the line joining the headlands at a distance of five miles, and the others shall keep the same line at a distance of ten miles. In case of collision, through neglect of this rule, the excuse of the outside vessel would be that she was complying with the rule requiring her to keep ten miles from the land. If the sweep of the land between headlands were five miles from this line, this would be true.

Appendix, Rules of the Road, p. 7, A. The same ambiguity is involved in this sentence as in the former one, Article 2, p. 3. As in the former case, the pronoun "she" refers, from the construction of the sentence, to the wrong vessel.

Page 10, 1. "A having a less speed than B, a very simple construction shows that A bears from B at a smaller angle than B bears from A;" the only condition given being that A sees B's green light to port at less than two points from A's course. I do not see that the above follows from the condition given, nor do I see that the speed of a vessel has anything to do with her bearing from another at any instant, which is made in 2 and 3 to alter the conditions.

The following illustration demonstrates the pernicious character of Article 2, p. 3, as it stands:



According to the article, A should port. The consequence would be a collision in nine cases out of ten. If B ports also, it would be worse.

I think Lieutenant Fletcher's plan of lights should be adopted. It might be just as well to keep the side lights in addition to those he suggests; but they should show from right ahead to right astern on each side. This plan without the side lights would enable a vessel to determine another's course at night sufficiently close for practical purposes. The present scheme, which leaves a sailing vessel without any lights from two points abaft the beam round by way of the stern to two points abaft the beam on the other side, renders it impossible for a steamer overtaking her to see her until her hull is lit up by the steamer's mast-head light. I myself narrowly missed a vessel on one occasion, only perceiving her by the light of my own mast-head light thrown on her mainsail.

I consider the endeavor to make a sailing vessel equally responsible with a steamer particularly vicious. In general it is easier for a steamer to clear a sailing vessel than for the latter to get out of the way of a steamer, and only special cases, where the sailing vessel can evidently better manœuvre, should be set for her to manœuvre. We should be very cautious about infringing on the sailing vessel's rights, it being admitted that she is the less easily handled. A sailing vessel close-hauled is at a disadvantage compared with one running free, and should not be subjected to the same responsibility.

It has been my observation that many, if not most, collisions are occasioned by both vessels attempting to manœuvre. I have always felt, when in charge of the deck at night, that the chief danger lay in the attempt of another vessel to get out of my way, when she should have kept her course. Therefore it is my opinion that, as far as it possibly can be done, it should be made obligatory upon one vessel to keep clear of the other, and for that other to keep her course. The only cases when this cannot be done are when two vessels meet end on, or when they are nearly so, and for this reason Article 2, p. 13, even if modified so that it could be understood, would be a very dangerous innovation. With the exception of the articles mentioned, and the regulations concerning lights, the suggestions of Lieutenant Hautreux and Captain Lanneluc are very good. Article 4, p. 3, might be very well amended so as to require the vessel firing the rocket to fire it in the direction in which she intends to go. But I emphatically oppose the attempt to make sailing vessels as responsible as steamers.

NEW ORLEANS, LA.

Lieutenant A. B. WYCKOFF.—In reading the translation of the pamphlet written by Lieutenant M. A. Hautreux, of the French Navy, and submitted to the International Congress at Washington by the Bordeaux Geographical Society, one is impressed with the impracticability of many of the proposed changes. That the present regulations for preventing collisions need careful and thorough revision is beyond question. But these should not be more radical than the necessities of the case require. Seamen are extremely conservative, and principles fixed by long years of experience should not be too rudely overthrown.

Article 1 of the General Regulations requires *all* steamers to carry electric lights—a measure wholly impracticable for small steamers, tugs, etc. The powerful electric lights have disadvantages as well as advantages, as all pilots will testify. The second white light proposed would probably not be higher than the pilot-house of large steamers, and could not be distinguished from other electric lights. The ability to place it on the head-stays, so that it could be seen and operated, is questionable, as well as its utility for determining the heading of the steamer when pitching and rolling in a sea-way. I presume the author does not intend that arc lamps shall be used, and dangerous currents led up the masts and rigging. If incandescent lights are intended, their life is very uncertain, and they would require constant watching, as well as time in replacing.

The necessity of sailing vessels carrying white mast-head lights would not exist, if rules with penalties were adopted requiring them to have side lights of sufficient power, always lighted when under way, and placed at a sufficient height above the water. The majority of sailing vessels have no fore-topmast cross-trees. No reference is made to a fixed stern light, which is absolutely necessary for the safety of slow steamers and sailing vessels.

More powerful sound signals are required, but the propositions of Article 3 are impracticable. Steamers use their whistles for a variety of signals, and would not readily substitute horns. It would also be difficult to get schooners to carry air-pumps and parabolic turning reflectors.

Article 1 of the Rules of the Road is what every deck-officer does at present, at least in a general way. Article 2 is radically bad, and is an amplification of the old "port helm" rule, which has caused a large percentage of all collisions. The officers of our Navy will remember the Oneida and Bombay, the Alert and Imperial Japanese Yacht, and many other instances. Porting the helm, when the other vessel is head on and even one-half of a point to starboard, would lead to many serious collisions. What is needed, particularly in this instance, is the second side light obscured for two points on the bow. A slight change of the helm would then open the after side light, when each vessel could go on her way at full speed, as safely as locomotives meeting on a double-track railroad.

Article 3, making a sailing vessel equally responsible, and governed by the same rules as a steamer, will hardly be accepted. Articles 4 and 5 ask a good deal from the ordinary sailing vessel, with perhaps two men on deck. How he expects them to make the frequent occultations of the mast-head light on sailing vessels does not appear. Article 6 is excellent.

The Special Regulations are very good, except Article 1. With ports near together it is impracticable; for, in many instances, one steamer would have to steam twice as far as another going in the opposite direction.

As I have already taken up too much space, I will not enter into a discussion of the points raised.

WASHINGTON, D. C.

NEWPORT BRANCH.

MAY 3, 1889.

The President, Rear-Admiral S. B. LUCE, U. S. N., in the Chair.

The paper was read to the meeting by Lieutenant H. M. Dombaugh, U. S. N.

The PRESIDENT.—The subject of this paper is one of the utmost concern to our profession, and the discussion of it is most timely. Of course, the greatest danger exists during fogs, and the rules should be especially discussed with this in mind.

We shall be pleased now to hear the opinions of any present upon this subject.

Commander GOODRICH.—I notice an absence of specific reference to the question of rules in time of fog—a time when rules will be most necessary. The whistles now used in American waters should be legalized.

A year ago Lieutenant-Commander Belknap proposed to signal the compass course steered, or within a point or so of it, by means of two steam whistles of different pitch or tone, in conjunction with a code dividing the compass card into sectors of from two to four points each. This is but a variation of an old theme, but to my mind it is the simplest and best of all the forms the idea has taken.

The proposed manner of lighting sailing vessels under way seems to be a logical deduction from the necessity of making vessel's lights more visible, as if one should say, Green and red are both faint, we must have a white light; when low down it can't be seen far, let us raise it. Thus we get in two easy stages to the white light carried at the mast-head.

I think Captain Mahan is right as to the division of responsibility for collision between the steamer and the sailing vessel. It is a delicate point, and vital to the whole discussion. Under this head, no ambiguity should be left.

The second white light on board the steamer is an old device. The late Lieutenant-Commander Gorringe in 1869 used to urge the necessity of range lights to indicate the direction of the ship's keel. He advocated, on board sailing vessels, one light at the flying-jibboom end and the other at the knightheads. The idea is a good one. The lower light ought to be carried always, and be so screened as not to shine in the eyes of the helmsman.

There is no objection to using the electric light on board of steamers, but steamers are not always supplied with dynamos, and the obligation to carry them would prove onerous in small craft. I like the idea of flashing the masthead light when the speed is above a certain figure.

It may be ungracious to speak of the article as we find it printed, but I think it always the duty of a translator to give an idiomatic version, not a literal and therefore obscure rendering of an author's text.

On one point in connection with all rules of the road, I think too much stress cannot be laid. They should be in the briefest and clearest terms. Your own ship should always be A, the vessel seen B. The verbal circumlocutions of the present rules should be absolutely suppressed.

The proposed injunction to keep a certain number of miles off shore is vague. Is the distance to be measured from the shore line or from a line running from headland to headland? And again, the weather might under certain circumstances be such as to make an infraction of the rule desirable, if not imperative.

On the whole, the essay will prove a valuable contribution to the literature of the profession in stimulating discussion where its provisions do not force themselves upon the universal conviction of seafaring men.

Vice-Commodore HANDY, R. I. Y. C.—The rules presented by the authors of this paper are based on very sound ideas, but it is not enough to have the rules; it is necessary also to have them carried out in a very thorough way and to have the spirit of the law as well as the letter observed. As an example of the way things go, we find, in cruising along our coasts, that while the coasting vessels obey the letter of the law, in that they have their "lights" lighted, yet in many cases the lamps are so poor, or the lanterns so foul, that the lights cannot be distinguished until one is close alongside. Provision should be made to meet such cases as this, or else the rules lose much of their value.

Lieutenant HUTCHINS.—In rearranging the Rules of the Road we should at least be influenced by a few general considerations. For instance, it is proposed to increase the number of lights carried by vessels. This would be unwise, for it frequently occurs now that in some localities a large number of lights suddenly become visible. This would be all the more perplexing if we increased the number on each vessel. Efforts should be made to increase the power of the lights we now have rather than to increase the number.

Again, it is proposed, under certain conditions, to give a steamer the right of way over a sailing vessel. I think a sailing vessel should always have the right of way, not only because she is dependent upon the wind for manœuvring, but also because the speed of the steamers that are being built from year to year is increasing, and hence the time allowed for a sailing vessel to manœuvre to avoid a collision after sighting a steamer becomes gradually less.

In regard to the colors to be used for vessels' lights, at least one of the lights should be that color which can be seen the farthest in a fog, for it is then we have the greatest chance of collision. This color we know to be red, and it is possible that a search light may throw such a red beam as can be seen a considerable distance even in a dense fog. A few experiments would settle this point. If such was found to be the case, a beam thrown in the direction of the course of the vessel would be a far more accurate indication of the course to another vessel than the method proposed of using two mast-head lights one over the other, and it would be preferable to a sound signal. At certain intervals the light could be trained to sweep the horizon, otherwise a vessel at right angle to the beam would not be able to make it out. It would probably not be necessary to use an arc light for this purpose, as it is claimed that incandescent lamp filaments can now be used in the focus of a projector.

I simply offer this as a suggestion that might be worth experimental inquiry.

Lieutenant HOLMAN.—*Mr. President*:—I would like to say a word in favor of doing away with red and green lights and substituting white range lights for them, as urged in this paper.

That range lights indicate with considerable precision the course steered by the vessel carrying them, whenever the weather is such that any lights at all are visible to neighboring observers, no one familiar with the aspect of our sound and river steamers at night will dispute. With range lights displayed, colored side lights are mere accessories, rather ornamental than useful.

Among the many reasons given in favor of abandoning the colored running lights there is one that I do not remember to have heard advanced, and that is, not the tendency, cited in the essay, to mistake red lights for white ones in foggy weather, but that of erroneously regarding green lights as white on even the clearest nights.

Who among us, while standing watch at sea, has not had the familiar experience of seeing a light, which, showing white at a distance, and no great one at that, gave evidence when close aboard of being intended for green? The effort to avoid lessening the brilliancy of the lights by putting as little coloring matter as possible in the glasses is sometimes carried to a harmful extreme. A small quantity of red in a shade or in a lens will make an unmistakably red light, but a small quantity of green may render close inspection necessary to the perception of any green tint whatever.

Should the International Congress, in considering the matter of lights, deem a conservative policy the better one, and decide to retain the present system, I hope it will decree a standard so that red lights, wherever met, shall be red of uniform intensity of color, and that green shall be green, also of a determined intensity and not, as at present, ranging on the one hand from red to pink, and on the other from dark green barely visible, to pale green with difficulty discernible from white.

Professor Munroe.—This matter of which Lieutenant Holman has spoken is one to which Dr. B. Joy Jeffries, the well-known authority on color-blindness, has given considerable attention. Some ten years ago he urged the adoption of standard colored lanterns by the U. S. Board of Supervising Inspectors of Steam Vessels, and he induced the New England Glass Company to attempt the manufacture of the proper glass. His efforts were so successful as to result in the following order:

"Treasury Department,
"Washington, D. C., March 18, 1881.

"*Agent New England Glass Works*, 67 *Federal Street*, *Boston*, *Mass.*

"*Sir:*—You are hereby authorized to furnish to each of the thirty-six boards of local inspectors of steam vessels named in the enclosed list, one red and one green lantern of the exact shade of colors of the samples furnished by your company, and now in the office of the Supervising Inspector General, which have been adopted by the Department as the standard shades to be used on steam vessels of the merchant marine of the United States, in accordance with the resolutions of the Board of Supervising Inspectors of Steam Vessels adopted February 4, 1881. Very respectfully,

[Signed] "Chas. J. Folger, *Secretary*."

I am not cognizant of what further action has been taken in this matter, but I can readily understand that many difficulties intervene to prevent the securing of colored lanterns optically similar in every respect.

Rear-Admiral Luce. — In my humble opinion no hard-and-fast ironclad "Rules of the Road" will supply the place of that skill in the handling of a vessel at sea, and the judgment which controls action in emergencies, which comes of experience. Lieutenant-Commander Hautreux, the author of the paper under discussion, seems to recognize this truth. He lays down two good rules under head of "Special Regulations":—

"Article 4.—On board all vessels carrying passengers, *the officers* keeping watch *must be licensed for long voyages* or for coasting vessels.

"Article 5.—On board every vessel making either long voyages or coasting trips, *the watch officers must possess certificates of fitness.*"

And again, under head of "General Regulations":—

"Article 4.—We believe that the regulations should *require* from all persons called, even temporarily, to take charge of the vessel, guarantees of technical knowledge and ability that would give that security which it is only right to exact for the passengers and cargo. This obligation is all the more necessary where the vessel carries passengers or emigrants. It is by hundreds that we count the human beings who confide in the professional ability of those who have charge of the vessel. *A knowledge of the rules of the road should constitute part of the qualifications exacted of candidates for positions on foreign-going or coast-wise vessels.* The duties of the officer of the watch, by night as well as by day, are filled by seamen of whom no legal guarantee is exacted. There are certainly careful seamen, keeping a faithful watch; but it is as certain that a great number among them have an incomplete knowledge of the 'rules of the road.' A certificate of ability is required in the naval service to fulfill the duties of the seaman and petty officer, and there should be no difficulty in exacting an analogous guarantee of every seaman seeking service as watch officer on board a merchant vessel."

Farther on he remarks that—

"It is in view of this simplification that we demand that all persons performing the functions of officers on board ship should be supplied with certificates stating their perfect knowledge of the rules of the road.

"In these notes that we submit to the Congress of Washington we do not pretend to solve all the difficulties that pertain to the question of collisions. We have wished to call attention to the necessity of a better method of signaling the sailing vessel, to simplify the rules of the road, and to exact a *certificate of ability from every person desiring to be charged with the conduct of a vessel.*"

I cannot too earnestly commend to the attention of those interested in this very important question the remarks above quoted. For, however good the "Rules of the Road" may be, it is, after all, the cool head and the steady hand that is to be relied upon to avert threatened danger.

This point has been recognized in the United States and an attempt made to provide for it. House of Representatives Bill No. 1347, of January 17, 1874 (43d Congress, 1st session), was to amend the act to provide for the better security of life aboard ship.

The first section provided for examinations of persons intending to become masters or mates of merchant vessels.

The fourth section provided "That there shall be delivered to every applicant duly reported by the Board of Examiners to have passed the examination satisfactorily, and to have given satisfactory evidence of his *sobriety*, *experience*, *ability* and general good conduct on shipboard, *a certificate of competency*," etc., etc.

Section 5 made it unlawful for an American ship to go to sea unless her officers were properly certificated, under a penalty of not less than one thousand dollars.

Section 12 provided for the establishment of nautical schools where those desirous of qualifying for the mercantile marine could obtain the requisite instruction. This was the origin of the "Public Marine School Bill," and the only part that became law.

Section 15 required that "all foreign-going sailing ships" shall take out boys in numbers proportioned to their tonnage.

Section 16 made it lawful to indenture boys, with the consent of their parents, to serve in trading ships until they shall arrive at the age of 21.

This was a wise measure for the prevention of collisions at sea by training up boys for the trade of seamen, and requiring officers to be certificated as to their ability to perform their duties. The bill in its entirety failed at the time, but another effort should be made to secure the favorable consideration of Congress.

There is one other passage in Lieutenant-Commander Hautreux's paper to which I will briefly allude. On page 5, Article 3, he says:

"In time of fog, the sound signals will be operated by compressed air.

"It is no more difficult to use compressed air on a steamer than to use steam; the use of the latter is subject to great inconvenience by reason of the condensation in the leading pipes, obstructions or choking of the pulley, and the feebleness of the sound at the beginning.

"With respect to the sailing vessel, the actual operation of the trumpet, produced by means of the human breath, is of little importance and has no great range or capacity. *It is not difficult to compress the air by a hand pump within reach of the lookout on the bow, and then to use the steamer's whistle on board of the sailing vessel,* while the steamers make use of powerful horns."

The great value of a good system of fog signals cannot well be overestimated in this connection. The best now known is the "Crosby Automatic Signal," designed for the express purpose of preventing collisions on the water during fogs. It gives a uniform and perfectly reliable action of the steam whistle or horn, and ensures continuous operation without the aid of hands, thus leaving the lookout or watch officer unembarrassed in watching for the approach of a stranger. The following brief description will give an idea of its character:

The signaling apparatus consists of a steam cylinder about 6 inches long by 2½ inches in diameter, a small single-acting balanced piston valve being fitted to the lower end. The steam admitted through the valve is controlled by a spring motor consisting of a simple clock mechanism occupying a space about 6 inches square. This motor is provided with a code cam or wheel that makes one revolution every two minutes, and can be set to actuate the valve, admit steam to the cylinder and raise the piston, producing blasts at such intervals and of such length as shall have been determined by the person in charge. The valve in the whistle or trumpet is opened by means of a cord attached to the lower end of the piston. The motor is self-winding, so that the machine will continue to run and signal so long as steam is admitted. A remarkable economy of steam is secured, there being no steam used except that required for the blast itself. In this respect the Crosby Signal is unique, and accomplishes a saving over all other appliances in steam, water, and coal, as proved by official tests at Sambro Light, of fully forty per cent.

When used on board steamers, the Signal is placed in the pilot-house within reach of the officer in charge. The code wheel is set according to the preference as to frequency and duration of blast, it being a very simple matter. On the approach of thick weather the captain or officer of the watch starts the machine by simply opening a steam valve and turning a thumb-screw. This being done, he is relieved from all concern as to his own signaling, and enabled to concentrate his attention on approaching vessels. It is believed that many collisions occur by reason of the attention being divided. It is reasonable to suppose, too, that sometimes there is an omission to signal on account of the concentration of mind on the lookout. Should there be an approaching vessel, the officer of the watch can instantly interrupt the automatic action and give such signals by hand as the occasion requires.

An apparatus of this character is already in operation at the Beaver Tail Light Station, and is believed to have given great satisfaction. By a simple device the Crosby Automatic Signal can be used for signaling by the Morse Code.

It gives such ample promise of success as to warrant trial in the Navy and on board some of our ships that frequent our own coast.

I have nothing to add, save to express my appreciation of Lieutenant-Commander Hautreux's comprehensive and well-considered paper.

Lieutenant JOHN WYCKOFF, U. S. R. M.—After carefully reading the subject under discussion, and after having talked the matter over with a number of captains and pilots of both seagoing and coastwise vessels, and from my own personal experience at sea and in enforcing the present laws, I fail to see the need of any such radical changes in the navigation laws as proposed; I cannot see that they would be of any benefit in facilitating navigation. All express themselves as perfectly satisfied with the present system of lights. We furthermore agree that the plainer and simpler the rules of the road, the less the liability to accidents.

There should be a standard construction and power of lenses for the red and green lights as now designated by law, and vessels should be compelled to carry them, and the fine for such violation should be not only imposed but enforced. Vessels should also be required to burn a certain grade of oil of brilliancy of flame of a fixed candle power, in lieu of the low-priced oils and lenses now in use. They also should be obliged to carry their side lights not less than twelve feet from the water, and the light boards of sufficient length to prevent the lights from being seen across the bow. The clause about two vessels meeting and in danger of collision sending up skyrockets and then commencing the detonating signal to explain the why and wherefore seems perfectly absurd to me, for in clear weather with proper lookouts and good judgment no such condition of affairs would arise. In foggy weather it would be impracticable, as the vessels under such conditions would have either sunk or fouled each other. No doubt a better system of fog signals could be arranged, especially when one or the other condition arises from the overtaking or crossing the bows of each other: for instance, vessels meeting end on should blow one long blast to indicate port, two blasts to indicate starboard, and three short blasts to indicate full speed astern.

A vessel having another on her starboard beam should determine from the sound the apparent position of the approaching vessel, and should sound four short blasts, to signify I am crossing to starboard; on the port beam, two short and one long blast, I am crossing to port. Of course, this is open to suggestion for some more approved method. The present three long blasts should indicate a tow; any number of short blasts, attention whistles. A great cause of complaint in coastwise sailing vessels is the want of proper attention on the part of the masters to show the proper light or torch when being overtaken by a steamer. These matters should be so adjusted that the master of any vessel going contrary to the rules of the road, which compel him to go at moderate speed, or failing to show certain lights or take proper precaution, should be punished by fine or imprisonment or both, and be debarred from holding his position for a certain period. The rules of the road as they now stand in regard to lights, in my opinion as a mariner, as far as it may have weight, are now thoroughly understood, and any attempt to change, alter, or complicate the present system would not only jeopardize the vessels, but also imperil the lives of the crew and passengers, and retard rather than improve the present system. Enforce the existing laws, and I will venture to say there will be fewer collisions and less number of accidents and a greater degree of safety.

The Secretary of the Treasury, upon representation of the masters, is too apt, from motives of clemency, to remit the fine and impose some light penalty, which only tends to encourage negligence. If they are guilty of an infraction of the law they should be fined the full amount, and thus by making examples of a few, all carelessness may be obviated.

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

RIGHT OF WAY AT SEA.

How has a Merchant Vessel to Act when She Meets a Manœuvring Fleet?

[Translated from *Mittheilungen aus dem Gebiete des Seewesens*, Vol. XVI., No. 3, by Lieutenant-Commander E. H. C. Leutzé, U. S. N.]

The Supreme Court at Berlin has, some weeks since, decided a suit which has been pending for four years and which has been much talked about. It touches the question above stated. The international rules for avoiding collisions at sea do not, as is well known, give a fleet forming a tactical unit the right of way, neither has any country any law that gives its own war vessels such an advantage. As different German courts hold opposite opinions in this regard, we shall describe the case of collision and then quote several opinions.

The case is as follows: The steamer Hohenstaufen, of the North German Lloyd in Bremen, left Bremerhaven on September 3, 1884, bound to Baltimore. The weather was fine, calm, with smooth sea. At 1.25 P. M. the pilot left the vessel, and the course was set W by N½N magnetic. The officers of the vessel were at their stations; the captain, in charge of the deck at the time, being on the bridge, and the first officer with him. The second officer was at the wheel. When the course was set W by N½N, several men-of-war were in sight on the starboard side. They were steering a course almost at right angles to that of the Hohenstaufen, which would lead them across her course from starboard to port. When they were sufficiently close, the order "port" was given on board the steamer.

The men-of-war in sight on the starboard side were the Baden, Würtemberg, and Sophie, and at a greater distance were others. The three named vessels were in column, steering SSW. The distance (reckoned from mainmast to mainmast) between the Baden and the Würtemberg was 400 m., and that between the Würtemberg and Sophie was from 450 to 500 m. The nearest of the vessels farther astern was at least 1000 m. from the Sophie. The speed of the Baden and Würtemberg was 9 knots, and that of the Sophie from 11 to 13 (the accounts differ), so as to gain her proper distance, 400 m. The distance between the last two vessels was consequently decreasing.

When the captain of the steamer gave the order "port," the first vessel, the Baden, was three points on the starboard bow. As soon as the second vessel, the Würtemberg, was opened on the port bow, the captain of the steamer gave the order "steady," evidently with the intention of passing between the second and third vessels, *i. e.*, the Würtemberg and Sophie. The latter was at that moment three points on the starboard bow of the steamer and 450 m. from the Würtemberg. The captain of the steamer saw instantly that it would be dangerous to break through the line, and again gave the order "port" before the helm had been put amidships.

It seems that this sheering to starboard of the steamer was not noticed on board the Sophie, and it was thought that the steamer was trying to cross her bow; her helm was therefore put to starboard without slowing down. Suddenly, as the Sophie had fallen off to port about 10°, her commander saw that the steamer had her helm a-port, and gave the orders "slow down," "stop," "back," and "back full speed," to the engine-room in quick succession, and the order "hard a-port" to the wheel.

In the meanwhile it was noticed on board the steamer that the Sophie was falling off to port, and therefore the orders "starboard," "hard a-starboard," and "full speed astern" were given. The actions of the Hohenstaufen were indicated by the whistle according to the international rules. The vessels collided almost immediately afterwards, the steamer hitting the man-of-war on the port side abaft the fore-rigging at an angle of 51°.

The case was tried in the first and second instances by the Marine Board at Bremerhaven (Seeamt) and the Chief Marine Board (Oberseeamt) at Berlin. In order to fix the amount of damages and the responsibility therefor the case was taken before the Provincial Court and Upper Provincial Court (Landes- and Oberlandesgericht) at Hamburg, and finally before the Supreme Court at Berlin.

It seems that from the first instance the government commissioners laid particular stress on the fact that the Hohenstaufen was in the presence of a manœuvring fleet. This is already touched upon in the opinion handed down by the Marine Board at Bremerhaven, which gave an exonerating sentence. The following is an extract of this opinion: "We find the laws that govern the case in question in Articles 16, 18, 22, and 23 of the already quoted decree of January 7, 1880. These laws are equally binding on merchant vessels and on men-of-war. Special laws that give men-of-war advantages are not in existence. The application of these laws does not admit of any change when several men-of-war are combined in a fleet, as they take cognizance only of the manner of handling single vessels when meeting, and do not recognize a squadron as a unit that is to be given peculiar advantages. It is therefore impossible to blame Captain Winter of the Hohenstaufen, or criticise his action as contrary to existing regulations, because he undertook to cross the column between single vessels."

The Chief Marine Board at Berlin, however, reversed the above decision. We quote as follows: "Up to the present the case has been judged only from the standpoint that H. M. ship Sophie was a vessel acting singly. Actually the corvette entered into the composition of a squadron, and had previously to shape her actions according to the order of the squadron commander. The evolutions, for practice, of such a squadron are ordered by high authority, and are an integral part of an important public measure—the readiness for war of the empire. It is everybody's duty to respect and not to disturb such practices of the military power. Captain Winter not only lost sight of this duty, but also showed his want of discernment in not recognizing that at any moment the squadron commander might give an order which would make his plans for avoiding collision dangerous to his own and other vessels. With a little thought he ought to have seen that a vessel should keep at a reasonable distance from a manœuvring squadron to avoid accident, and that an attempt to cross a column of fast-moving men-of-war is an indiscreet risk of human life. The fact that Captain Winter did not know that the Sophie was obliged, under squadron orders, to close in her distance from H. M. S. Würtemberg from 500 m. to 400 m. was actually instrumental in causing the collision; for had he known it, he would hardly, even momentarily, have decided to pass between the two vessels mentioned."

It seems therefore that there would be every reason for depriving

Captain Winter of his certificate, for being wanting in the qualifications necessary for exercising the profession of a seaman, were it not for two circumstances that allow a less severe judgment. As the second mitigating circumstances, it is mentioned that the captain had never served in the Imperial Navy, and consequently had no idea of the problems and manner of performing fleet evolutions, and the serious consequences that a disturbance of such exercises may cause.

The Upper Provincial Court at Hamburg, which also acquitted the captain of the Hohenstaufen, opens its opinion with a criticism on the above decision. It says: "In judging this case, we start with the principle that the international rules for avoiding collision at sea, which are contained in the decree of January 7, 1880, make no difference between men-of-war and merchant vessels, and do not recognize a fleet as a unit that is to be treated like a vessel sailing alone. Neither are there any other laws or customs that require from masters of merchant vessels a special mode of procedure when meeting war vessels. This principle was acknowledged by the plaintiff side, by the declaration that in relation to the international rules of the road, vessels of the Imperial Navy do not claim any privileges. This declaration cannot be reconciled with the opinion that in the meeting of the vessels in question, the corvette Sophie had previously to shape her movements according to the orders of the squadron commander, that consequently the master of the Hohenstaufen should have recognized that at any moment an order unknown to him might frustrate his plans to avoid collision and jeopardize his and other vessels. This was in nowise to be feared, and therefore should not be taken into consideration. For as soon as the Hohenstaufen and Sophie came into position where the application of the international rules became necessary, both commanders had not only to be guided, but to be guided exclusively by these rules. Captain Winter was justified, without any further thought, in assuming that from the moment that he recognized his duty according to Article 16 to change his course to starboard in order to avoid the crossing men-of-war, said men-of-war should not have performed any evolutions, but have held their course, according to Article 22, until clear of the Hohenstaufen. In the absence of any law or custom, it cannot be expected from masters of merchant vessels to treat a squadron of war vessels differently from a number of merchant vessels that happen to be sailing together. Masters of passenger, freight and mail steamers are always required to proceed with the utmost dispatch and promptness, and it certainly cannot be demanded of them that on a frequented route, and when pursuing a set course, to shape their actions by any other considerations than those required by the law of all vessels, either to give way or to hold their course. For instance, they cannot be expected to bear in mind not to deprive a vessel in a squadron of temporary freedom of action. There is therefore no justification for the assertion of the plaintiff that (in spite of the admission that no difference is made in the rules of the road between vessels of the Imperial Navy and merchant vessels) Captain Winter is to be blamed for getting into a position where, in relation to a single vessel of a squadron, he had to obey Article 16, and for bringing the Sophie in a position where he must expect her to obey Article 22. A new principle, giving a manœuvring squadron undue privileges, is formulated when masters of vessels meeting such a squadron are required not to shape their actions according to the international rules of the road and general nautical considerations. In deciding the question of guilt in this case, only such rules are admissible as are applicable to colliding steamers. All claims of the plaintiff arising from the fact that the Sophie was part of a manœuvring squadron are of no value in this suit, and cannot be taken into consideration in giving judgment."

The Supreme Court pronounces decidedly in the sense of the Berlin Marine Board, and remarks as follows: "The opinion is wrong that the Court of Appeals states on sheet 23, etc., that the decree of January 7, 1880, does not recognize the idea of a squadron that has the right of way as a complete unit. The point is not how a single vessel has to behave when there is danger of collision. It is the opportunity of collision that Captain Winter ought not to have brought about. And in this respect we thoroughly concur in the opinion of the Chief Marine Board, that masters of vessels ought, if possible, to remain at such distance from a manœuvring squadron that any sudden order of the squadron commander cannot frustrate their plans and jeopardize their own and other vessels. It is not to be taken into consideration that the observance of this precautionary measure is impracticable because the navy might thereby put obstacles in the way of trade, or that a much frequented marine highway should be blocked by a fleet for any length of time. The appellants themselves cite par. 33, Art. 4, of the instructions of squadron commanders, in which the placing of such obstacles are from the beginning prohibited. In the present case the squadron steamed in close order towards the mouth of the Jade. It could have been a matter of only a few minutes to the Hohenstaufen to let the whole squadron pass her, and less time still to pass between the third and fourth vessels, which had considerable distance between them."

The decision of the Supreme Court created quite a sensation in professional circles for two reasons: First, because the Hanseatic Upper Provincial Court enjoys a great reputation on nautical questions, and because it has always been the custom to lay great stress on its decisions; second, because the Supreme Court does pronounce in a more or less formal manner that the merchant vessel has to respect a squadron. It seems to us, however, that from a legal and professional point the case is not so easily disposed of, and that the decision of the Supreme Court has not enough foundation.

It also seems to us that the decision of the Upper Provincial Court is not sufficiently explicit. To the opinion of the Hamburg Marine Court should have been added that it was a question of international law, a fact that seems to have been overlooked both by the Upper Provincial and the Supreme Courts. It might be possible to exact some consideration from merchant vessels of one's own nation (though even this is not founded on law), but none at all from foreign flags. Had the Hohenstaufen been a foreign merchant vessel, the opinion of the Berlin Chief Marine Board would have been without foundation, and therefore equally without foundation for a German vessel, because the case has to be judged according to an international law in which there is no question of the colliding vessels' nationality.

A dangerous precedent, which can have evil consequences, is established by the fact that the Supreme Court of Berlin affirmed the decision of the Chief Marine Board. Let us assume, for example, that the case of the Hohenstaufen should be repeated under the following circumstances, *i. e.*, suppose she had been a German man-of-war on an important mission, where every moment was of the greatest consequence: who should give way? Who is to judge which is the more important mission, that of the single vessel or that of the man-of-war? Generally speaking, as soon as a precedent is established, many doubtful cases arise. Suppose, for instance, the steamer had been a yacht with the high, or the highest personages on board: should she then let the entire squadron pass her? And how should two squadrons or two divisions of squadrons act were they to meet?

Such considerations are not tenable in international intercourse, and are in fact impossible to be observed, and should not be demanded.

It has not yet been taken into consideration in the supposed cases that the collision took place at sea, how a vessel should act were she suddenly to meet a squadron when rounding a point, or while she was clearing danger, or when running into the entrance of a channel.

It would seem that the decisions of the Chief Marine and the Supreme Courts have created a flaw in international law that might bring about the most serious consequences, and for that reason these decisions have caused a sensation in professional circles, and have given rise to very decided expressions of opinion.

The editor of the *Mittheilungen* thinks that this flaw has not been created, but has been and is in the international rules of the road. Merchant vessels will always demand that squadrons of fleets shall not become an obstacle to trade, while on the contrary, men-of-war will always demand that they shall be disturbed as little as possible by merchant vessels in their squadron evolutions. It is an international question that cannot be settled by one side, but only by an international convention.

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U. S. NAVAL INSTITUTE, NEWPORT BRANCH,

APRIL, 1889.

NOTES ON THE LITERATURE OF EXPLOSIVES.*

BY CHARLES E. MUNROE.

No. XX.

From the Annual Report of the Chief of Engineers, U. S. A., page 353, part 1, 1888, we learn that a series of experiments was made at Willets Point by Major King, to ascertain the form and dimensions of the craters produced by different charges of explosives fired at various depths below the surface of the water.

These experiments were in continuation of some investigations made by him twenty-three years ago, when the first recorded attempt was made to measure the force of submarine explosives.

The apparatus consisted of a wooden frame 15 feet by 18 feet square, with a thin iron ring just below the center; this ring being held in position by 16 radial wires, making angles of 22½ degrees with each other, and having their outer ends attached to the wooden frame. Upon each wire was placed a small sliding block of hard wood 2 inches in diameter at the end towards the ring and much smaller at the outer end, the length of the blocks being 4 inches and their density about the same as that of water. A small piece of rubber tubing was placed on the wire outside each block, the object being to record the distance to which the blocks were forced outward by the explosion of the charge, which was placed in the center of the ring.

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*As it is proposed to continue these Notes from time to time, authors, publishers, and manufacturers will do the writer a favor by sending him copies of their papers, publications or trade circulars. Address *Torpedo Station, Newport, R. I.*

The charges were inclosed in paper cartridges coated with paraffine, and were exploded with platinum fuzes containing only a little granulated gun-cotton instead of the usual priming of mercuric fulminate. The charge was generally of musket powder, only a few of dynamite having been tried.

The frame containing the ring and charge was lowered vertically into the water to the desired depth, and after firing, the charge was raised and the distance to which the sliding blocks were forced back was carefully measured and plotted. In a few cases the water appears to have leaked into the charge and somewhat reduced all the indications of that round; but, on the other hand, as nothing could have caused any excess in the result, it is safe to assume that the maximum set of indications for a given charge were very nearly correct.

Although but few experiments were made, the following conclusions were thought to be warranted:

When a charge of either gunpowder or dynamite is fired under water, a large volume of water is displaced, forming a crater or cavity, spheroidal in general shape and varying in size according to the weight, nature of charge and depth in the water.

There appears to be a strong tendency to retain the spheroidal form, even when the depth below the surface of the water is considerably less than the line of least resistance that would give a "common mine crater" in ordinary earth with the same charge.

Charges exploded near the surface give larger craters and greater depressions below the center of the charge than those fired at greater depths.

While the surface of the cavity formed by the explosion is generally quite regular in form, there are frequent exceptions to this rule, which indicate that for some reason the expanding gas sometimes sends out small jets to a considerable distance beyond the general surface of the cavity. These jets are sometimes downward, but oftener in an upward direction, as would be expected.

By standing on a wharf nearly over the smaller charges when they were fired, it was noticed that the inflamed gas formed a well-defined ball of fire, and by means of photography some tolerably successful efforts have been made to catch a view of what takes place at the very instant of explosion.

The action of dynamite in forming a crater seems to be quite similar to that of musket powder, though, of course, a much smaller charge produces an equal cavity.

A few experiments were made with paper disks secured to a large iron ring, which was used in the same way as the crater-gauge already described for getting the form and size of the cavity formed by the explosion of small charges of powder and other explosives under water, but no satisfactory results have been obtained, as the paper manifested a disposition to tear out radially in such a way as to make it uncertain how much of the effect was due directly to the explosion and how much to the action of the water.

The report is illustrated with drawings and charts.

Experiments were made at Fort Lafayette, January 19, 1889, to test the new pneumatic dynamite gun. Two rounds were fired, one of which contained 300 pounds of explosive gelatine and 200 pounds of dynamite, but, according to the *Providence Journal* of January 20, 1889, both fell from 240 to 300 yards away from the target. The experiments were resumed January 26, eight rounds being fired at an imaginary rectangular target, 150 x 50 feet, placed at a distance of one mile. The gun was a 15-inch one, but the projectiles were sub-caliber, battened with wood and rubber so as to fit the bore. One of the shells contained 201 pounds of explosive gelatine and dynamite, the latter being a small proportion; the rest contained 175 pounds of explosives each, of which fifty per cent was dynamite. Four of the eight shells missed the target, one of which broke up in the air shortly after leaving the gun, while another apparently failed to explode until it had touched bottom.—(*N. Y. Herald*, January 27, 1889.)

The report of the Naval Board on the trial of this gun appears in the *Army and Navy Journal* **26**, 547-548; 1889, together with the endorsement of the Secretary of the Navy. Twenty-four rounds were fired January 19, 26 and 31, part of the shells being loaded with explosives and part with sand, the object being to demonstrate the capacity of the gun to throw 200 pounds of high explosive between the limits of at least a mile and 200 yards, grouping 50 per cent of the shots of each series in a target 150 feet long by 50 feet wide. Through some error, the dynamite provided was of less density than had been specified when the sub-caliber projectiles were designed, and they were found to hold but about 170 pounds of the explosive. However, in firing these same projectiles for range from the same 15-inch gun, one containing 220 pounds of sand was thrown to a distance of 1.75 miles; a second containing over 200 pounds of explosive gelatine was thrown 1.19 miles, and a full-caliber projectile containing 500 pounds of sand was thrown to within 50 feet of one mile.

As regards the accuracy of fire, the Board reports that from the experiments it appears "that projectiles either carrying or capable of carrying 200 pounds of high explosive were thrown to distances varying from 1¾ miles to 90 yards, and that, at the ranges selected for grouping, viz. 2100 yards, 1700 yards and 360 yards, not less than one-half of the projectiles fired fell in the same standard target with the trial shot."

In the same number of the *Army and Navy Journal*, 560-561, is an abstract from the *Congressional Record* of a memorandum inserted by the Hon. Eugene Hale, on the U. S. S..Vesuvius, in which, after giving an historical account of the vessel and her armament, and drawing a comparison between her and foreign torpedo-boats as regards size, speed and the like, he says: "With regard to the relative effective power of these vessels as compared with the Vesuvius, it is necessary to revert to the comparison heretofore made between the effective zones of locomotive and aerial torpedoes respectively.

"All of the European torpedo-vessels being armed with locomotive torpedoes, it follows that their effective zones must be limited by the sure striking range of those missiles, which has been demonstrated to be about 600 feet in still water. What they would do in a heavy sea is still entirely a matter of conjecture, whereas the effective range of the aerial torpedoes of the Vesuvius has been demonstrated by official trials in the harbor of New York to be more than one nautical mile, and effective shots have been made up to 9000 feet, or a mile and a half. In short, so far as range and accuracy are concerned, there can be no common ground of comparison between torpedoes thrown through the air by a constantly controllable force, and torpedoes launched in the water to make the best of their way without further control or guidance.

"The following comparative statement shows more clearly the relative powers of these different types:

"Vesuvius.—Number of torpedoes, 30; maximum weight of each, 500 pounds of explosive; effective range, 6000 feet; rapidity of fire, three shots in two minutes.

"Iljin.—Number of torpedoes, 21; maximum weight of each, 180 pounds of explosive; effective range, 600 feet; rapidity, estimated once, in six minutes for each tube.

"Tripoli.—Number of torpedoes, 20. Other conditions as above.

"Destructor.—Number of torpedoes, 15. Other conditions as above.

"Sharpshooter.—Number of torpedoes, 20. Other conditions as above.

"Rattlesnake.—Number of torpedoes, 16. Other conditions as above.

"Bombe.—Number of torpedoes, 10. Other conditions as above."

The *Newport News* of April 4, 1889, states that on April 2 a preliminary trial of the pneumatic guns of the Vesuvius was made, in accordance with the agreement with the Government that before they are accepted they must have been fired five times in ten minutes, and that at this trial ten blank shots were fired in eight minutes. Starting with her three guns loaded as for battle, the trial proved that the Vesuvius could fire eighteen shells, each containing 500 pounds of explosive, in six minutes, or during the time which it would take her to steam 2¼ miles.

In addition, the results of forty blank shots demonstrated that the valve mechanism is now so perfected as to control the final air pressure, when the pressure in the reservoir is 1000 pounds, with great nicety.

In the same journal of April 26, 1889, it is stated that on April 24, during a preliminary trial on board the Vesuvius to demonstrate that a two hundred pound shell could be thrown to all ranges inside of two miles and at the rate of one shot in two minutes, an accident occurred which will delay the preparing of the vessel for sea.

Three dummy shells were successfully fired, the range being a little less than one mile. A fourth shell was then inserted which was different from the first three, as it was a ten-inch sub-caliber cast-iron one weighing 500 pounds. It was placed in the middle of the gun, and when the gun was fired the shell went to pieces in the bore. As a result, the breech of the gun was badly wrecked and considerable damage was done to the mechanism, but nobody was injured.

U. S. Letters Patent No. 397052, of January 29, 1889, have been granted Stephen H. Emmens for a "gun and projectile for throwing high explosives," in which gunpowder guns are utilized as propelling agents, by making the projectile, which is charged with high explosives, thimble-shaped, so that it may be slipped over the chase.

We are in receipt of a reprint from the *Congressional Record* of February 8, 1889, containing the remarks of the Hon. Levi Maish in offering an amendment to the Army Appropriation Bill, which appropriates $15,000 for testing the plan proposed by Stephen H. Emmens for converting existing ordnance of the War Department into steel-lined torpedo howitzers for throwing high explosives, and to which Dr. Emmens' memorial is attached.

From this it appears that he proposed to convert the M. L. 15-inch Rodmans into B. L. torpedo howitzers by boring through the existing breech and inserting a short lining tube of steel, which is fitted internally with an interrupted screw for the reception of a movable breech-plug, the construction of which constitutes the main feature of the converted gun. A central cylindrical hole extends through the plug, and other cylindrical chambers of larger diameter extend from the front of the plug rearwardly into its substance. These chambers contain the gunpowder forming the propelling charge, and a starting charge is placed in the central cavity, which is closed in the rear by a subsidiary breech-block carrying a firing-pin or other suitable ignition device.

The torpedo to be fired from the gun is an elongated shell charged with high explosive, and having its base extended backward in the form of a stud which fits in the central cavity of the main breech-plug. Hence, when the starting charge is exploded, a relatively weak impulse is communicated to the torpedo, which commences to move forward at a moderate rate of speed, and then, immediately the stud leaves the central tube, the heated gas inflames the main portion of the charge in the surrounding chambers, and these burn from the front backwards, keeping up an evolution of gas which urges the projectile forward throughout the whole length of the gun.

By this device the shock of firing is reduced to a minimum, and a comparatively uniform pressure is maintained until the shot leaves the gun. It will also be obvious that by suitably adjusting the air-spacing of the several sections of the charge, and by properly selecting the character of the powder employed, the pressure may be fixed at 10 tons per square inch or any other possible amount; while owing to the front ignition of the main sections, the whole of the powder may be utilized instead of being blown out in a partially consumed state, as is almost invariably the case in guns of ordinary types.

He proposes to use emmensite in his shell, and expects to be able with 115 pounds of powder to throw from these converted guns a shell containing 534 pounds of the explosive to a distance of three miles.

The *New York World* of January 22, 1889, devotes considerable space to the description of a method of defense of New York harbor in which petroleum is to be the active agent. It is proposed to lay a system of pipes along the shores of the Hook and Long Island which are connected with large reservoirs of petroleum and lead under water to the main ship-channels. The mouths of these pipes are to be closed by valves which are held in place by the pressure of the water, but which can be forced open by pressure applied to the fluid inside. The petroleum will thus be discharged into the water, where it will rise to the surface and be ignited by fire-balls, etc., which are thrown from the shore. It is hoped that the smoke produced will be sufficient to make navigation impossible, so that the vessels of the hostile fleet will destroy one another by collision, or that it will be dense enough to prevent them from using their guns, while they may remain sufficiently visible to serve as a target.

On November 21, 1888, an explosion occurred on board the petroleum-laden "ketch" United while lying in Bathurst Basin, Bristol Docks, England, which blew up the docks, killed three of the crew, threw the fourth into the water (whence he was recovered seriously injured), injured a policeman on the quay, shattered the glass in the windows about for a radius of ninety yards, and liberated and ignited the petroleum spirit, which destroyed the vessel and did further damage to the dock and the buildings about it.

The circumstances attending the explosion were thoroughly investigated by Col. V. D. Majendie, H. M. Chief-Inspector of Explosives, and made the subject of a special report to the Home Department. He found that the cargo consisted wholly of the petroleum designated in the trade as "Pratt's deodorized naphtha," and commonly known as "benzoline," it being an exceedingly light, volatile liquid, having a specific gravity of .7034, and giving off inflammable vapors abundantly even at the freezing point of water; that there were 310 barrels of 40 gallons each in the hold, which was separated from the forecastle and cabin by 1½-inch thick, close-joined (tongued and grooved) bulkheads without any openings whatever, though they were not air-tight; and that the natural leakage from the cargo during the time it had been in the hold was sufficient to have rendered the atmosphere of the vessel between decks thoroughly inflammable.

He found that there had been no attempt to conceal the explosive and inflammable nature of the cargo, but that on the contrary everybody connected with the handling and transportation had been repeatedly warned not to have any fires, lights or matches about the vessel, and that a policeman had been stationed on the quay to see that the prohibition was enforced; yet in spite of this, Col. Majendie was led to the conclusion that the explosion was caused by some one's striking a match in the cabin, by which the inflammable vapor, which had reached that portion of the vessel, was ignited and immediately carried the flame forward to the hold. This conclusion is strengthened by the fact that the master of the vessel exhibited considerable impatience at the restrictions placed upon him, and intimated that an unnecessary amount of fuss was being made about the cargo, as he had been used to carry dynamite and never had had so much fuss made about that, which showed that he failed to appreciate the fundamental distinction between a cargo of dynamite and one of petroleum spirit, viz. that in the case of the former an explosion from fire cannot take place unless fire be brought to the dynamite, while in the case of the latter the dangerous vapors will travel to a fire at considerable distances and even through intervening bulkheads; so that, while one might have had fires and lights in the cabin without serious danger when dynamite was on board, yet with petroleum spirit in the cargo it was almost certain to lead to disaster.

It was further found that the vessel itself was wholly unsuited for the use to which it had been put; for vessels in which the cargo in the hold consists wholly or partially of petroleum spirits or similar highly volatile and inflammable liquids, should have all cabins and galleys on deck, while the cargo should be battened down, and no one should be permitted below during the voyage.

In the course of this investigation several interesting experiments were made. Thus Dr. Dupré showed that one volume of the liquid naphtha, such as was on board the United, would render 16,000 volumes of air *inflammable* (one cubic inch to 9.2 cubic feet of air), or 5000 volumes of air *strongly explosive*, while it would render 3000 volumes of air combustible but only slightly explosive. He found, too, that one volume of the liquid yielded 141 volumes of vapor at the ordinary temperature, so that one volume of the vapor would render 113 volumes of air inflammable and 35 volumes of air strongly explosive.

From the experience at the largest petroleum stores in London, it was estimated that the normal rate of evaporation of such petroleum spirits when in sound barrels and good condition was about 16 per cent per annum, which for the quantity on board the United would give a normal daily rate of six gallons, and this would be sufficient to render 5000 cubic feet of air explosive.

To determine whether or not a mixture of petroleum vapor and air may be ignited by means of an ordinary spark, Dr. Dupré and Colonel Majendie repeatedly placed the incandescent end of a freshly extinguished wooden match in a jar containing the mixture, without firing it. When a flaming match was introduced, ignition or explosion invariably ensued.

The same results followed when incandescent match-ends were introduced into a wooden box in which the evaporation of petroleum spirit had been established, while on all occasions the flaming match produced ignition.

Showers of sparks from a flint and steel were repeatedly produced inside a box charged as last described without causing ignition, while pieces of red-hot coal were held over a small quantity of the petroleum spirit which had been spilled on a wooden floor, and in one or two instances particles fell on the liquid also without causing ignition.

A platinum wire was introduced into a jar of the mixture and heated by a current. So long as the wire was at a low or red heat no action ensued, but when the wire approached a white heat explosion invariably followed.

Mr. Boverton Redwood has also made some experiments with mixtures of air and benzoline vapor which are interesting in this connection. He introduced some of the Japanese parlor fireworks (known as "scintillettes") while they were emitting brilliant sparks but after they had ceased to flame, into a jar of this mixture, and the latter was not ignited, but it did ignite immediately on the application of a flame. Then he introduced a "fixed star" vesuvian (as used by smokers) immediately after it had ceased to flame, and while combustion was proceeding from the point to the head, into a similar jar of the vapor, and the incandescent mass remained in the vapor until it had cooled, but without igniting the vapor. Then he attached two fuzees or vesuvians (of the non-flaming description) to a wire, so that the tip of one was in contact with the head of another. He ignited the latter, and as soon as it had ceased to flame, he plunged them into a jar of the vapor, where they remained, while the combustion proceeded from the tip to the base of the first without effect; but immediately that the combustion extended from the base of the one to the tip of the other and a *flame* was produced, the contents of the jar were inflamed and exploded. Finally he allowed a stream of sparks from the fireworks known as "Golden Rains" to fall into a jar of the vapor, and again no ignition ensued.

These experiments may be performed with a mixture of one volume of the liquid to 6000 volumes of air, this being found to be the most explosive mixture.

As is customary in these admirable reports by Colonel Majendie, he gives here a résumé of the more important instances of similar accidents which are on record, and it is interesting to note how comparatively slight the damage done by the oil burning upon the water is and how easily its spread is arrested. Thus in the case of the United, though another vessel which was not more than 40 feet to windward from her was surrounded by flames from the burning spirit, yet she escaped unharmed, and the flow of the spirit was arrested by means of booms.

Through the courtesy of M. P. F. Chalon we have received a copy of a trade pamphlet of some 40 pages, entitled "The New Explosive, Bellite," which contains the reports of tests of this explosive made at different times by the Association of Chemists at Stockholm, Lieutenant C. O. Nordahl, Professor P. T. Clève, P. F. Chalon and A. W. Cronquist, together with various press notices of its use, all of which tend to show the great efficiency, permanency and safety of the explosive.

Among the more striking of the experiments described is that of heating the explosive in a covered platinum crucible by means of a blast-lamp, when the explosive burnt away with flame, but without explosion; and that of igniting a portion which was placed in a mixture of sulphur and potassium chlorate, where it also burnt without explosion. Other experiments given in the pamphlet have already been cited in these Notes.*

Chalon states in his report that bellite consists of ammonium nitrate five parts and dinitrobenzene one part; that it is offered both in the form of powder and of compressed cartridges, is of a yellowish color, almost dry to the touch, and resembles ammonium nitrate in smell and taste.

On February 5, 1889, an experimental exhibition of the properties of bellite was made at Wangey Hall Farm, Chadwell Heath, England, in the presence of a large number of visitors, an account of which is given in the *Engineer* **77**, 116–117; 1889.

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* Proc. Nav. Inst. 13, 247–248 and 579–581; 1887.

The inventor claims for bellite the following advantages: 1, That bellite is one of the most powerful explosives known; 2, that it is more powerful than either gun-cotton, dynamite, or gunpowder; 3, that it possesses qualities of safety entirely foreign to explosive substances generally; 4, that bellite presents no danger whatever in manufacture; 5, that it cannot be made to explode by friction; 6, that it cannot be made to explode by shock or by pressure; 7, that it cannot be made to explode by electricity or by lightning; 8, that it cannot be made to explode by fire; 9, that it cannot be made to explode by any means except by the aid of a detonating cap, and is therefore absolutely safe; 10, that on being exploded, no noxious gases are given off, as is the case with dynamite and all nitroglycerine compounds; 11, that bellite made expressly for coal or rock blasting does not shatter like dynamite, but forces the coal or rock out in larger blocks, making but a very small percentage of dust; 12, that it does not undergo any chemical change from time nor from atmospheric influences, always retaining its non-explosive character until the fulminating cap is applied to it; 13, that it can be used in shells that would prove of a terribly destructive character. Dynamite cannot be so applied, as the concussion produced by ignition of the gun-charge would be liable to explode the shell and burst the gun. Bellite shells, however, may be fired without any such risk, thus solving the problem of firing high explosives from ordinary guns, hitherto an impossibility. 14, That bellite can be manufactured in tropical climates, which is not possible with dynamite; 15, that it can be transported by land or sea with perfect safety, being carried in Sweden as ordinary merchandise; 16, that it requires no thawing in the coldest weather, like dynamite, consequently much time is saved; 17, that it can be profitably sold at a lower price than dynamite or any other nitroglycerine compound. At present there are about 60 factories in Europe making dynamite and similar compositions, producing annually 40,000,000 pounds.

1. The programme was commenced by firing a charge of 1½ pounds of bellite in a can under water. As the bellite was enclosed in a water-tight case, there was nothing in this test to notice.

2. A bellite 4-ounce charge—which somewhat resembles a stick of sulphur with a perforation at one end—was broken in two, the solid end being thrown into a coal fire, where it melted and burnt without

attracting notice, and the perforated end being exploded by means of a fuze and detonator, on ⅜-inch boiler plate, which it bulged. This illustrated the fact that bellite will not explode by ordinary combustion, while its action on ignition by a detonator is very powerful.

3. An iron 120-pound weight was dropped from a height of about 16 feet on five charges of bellite laid on an iron plate. The first blow not being quite end on, this was repeated, when the bellite was crushed to powder without explosion.

4. The crushed bellite thus produced was then placed in a tin which held 5 ounces, and fired by a detonator in contact with an old S. E. R. iron steel-faced rail, which was fractured. This illustrated the power of bellite to resist explosion under a blow when in contact with iron.

5. In a hole 3 feet deep was buried 1 pound of blasting powder mixed up with naked bellite cartridges or charges, and the powder fired by a plain powder fuze, when the bellite was thrown about and blackened, and the surface burnt in places, but apparently none of it was exploded.

6. A charge of bellite was fired like a bullet from a small-arm, "No. 8," $\frac{15}{16}$-inch bore, against a ⅜-inch boiler plate. Bellite was found in small pieces adhering to the face of the plate unexploded.

7. The propelling power of bellite was next shown by the following experiment: A 32-pound shot was discharged from a short mortar, first by a charge of ½ pound of powder—Curtis and Harvey's—and then by ¼ pound of bellite. In the former case the shot fell at 40⅓ yards from the mortar, and in the second at about 95 yards, illustrating the great superiority of bellite over the double weight of powder fired under these conditions for propulsion.

8. Charges of dynamite and bellite, 4 ounces each, were placed on similar ⅜-inch boiler plates, and after being covered with clay, which was pressed over them, were fired. The effects were very nearly identical in this case. It is, however, said that experience has shown that the injury effected by dynamite is generally more local, and that of bellite more distributed.

9. The fuzes of mines in the earth charged with gunpowder and bellite were now ignited. The powder exploded, but the bellite fuzes failed.

10. A charge of 8 pounds (10s. worth) of bellite which had been buried 3 feet beneath a length of 60 feet of railway line laid in chairs fixed in cross sleepers with fishes, etc., complete, was now exploded by

the usual detonating fuze. The entire structure for many feet was lifted high in the air, the rails being both broken through in one place, while one rail was bent at some feet distance from the point of fracture, the fishes of the other rail being broken through at a nearly equal distance. The sleepers were torn and split and one chair broken. A crater was opened in the ground about 12 feet in diameter.

Some of its properties were necessarily not tested; for example, its freedom from all flame and the harmless character claimed for its products of combustion. Then, again, its power to explode when in contact with water was not exhibited. It may be noticed, in addition to what has been mentioned above with regard to the thirteenth claim put forward by the inventor, namely, its suitability for bursting charges of gun shells, that a delay-action arrangement has been devised to enable steel shells to perforate armor before explosion takes place.

In a lecture on "Blasting Gelatine and Bellite," given before the Philosophical Society of Kilmarnock by J. Guthrie Kerr, the lecturer stated that blasting gelatine (nitroglycerine 97 per cent and guncotton 3 per cent) was 50 per cent better in explosive effect than dynamite. It is entirely unaffected by water, and cartridges which have been immersed for seven years have at the end of that time developed their full power when detonated. Gelatine dynamite (blasting gelatin 80 per cent, wood-meal and saltpeter 20 per cent) is largely used in fiery mines in England as the charge in Settle's application of Abel's water shell.* This consists of a rubber bag filled with water, with the gelatine-dynamite cartridge held in place in the middle by tin supports. This cartridge requires large bore-holes, which is a disadvantage and expense, and hence bellite has been proposed for use in these mines, it being claimed to be 30 per cent stronger than dynamite, absolutely safe for transport, and flameless. As regards this last claim there seems to be a want of evidence as to the effects of other than comparatively small charges under favorable conditions. In the meantime the claim could not be considered as made good, whatever the promise might be. Compared with blasting gelatine, it is inferior so far as concerns the power of withstanding water, as might be inferred from the presence of such a large proportion of nitrate of ammonia. If as a protection against water it be

* Proc. Nav. Inst. 14, 766; 1888.

covered with a water-proof mixture, it becomes less adapted for filling holes.—(*Jour. Soc. Chem. Ind.* **8**, 213; 1889.)

In view of the attention which the nitro substitution compounds are now receiving, U.S. Letters Patent No. 157143, dated November 24, 1874, which were granted C. W. Volney for "Volney's Powder," may prove of interest.

His invention consists in mixing nitrated naphthaline with an oxidizing agent, the nitrated naphthaline being obtained by the action of nitric acid upon naphthaline. The result of this treatment is a yellow substance consisting of mono, di, tri, or tetra nitro-naphthaline, in which one or more atoms of nitrogen-tetroxide are substituted for the corresponding number of hydrogen atoms. Strong nitric acid and high temperature will produce the higher nitrated bodies, as di and trinitro-naphthaline. From weaker acid and lower temperatures mono and dinitro-naphthaline will result.

All these different nitro bodies will form useful explosive compounds when mixed with equivalent quantities of an oxidizing agent, which can supply sufficient oxygen to oxidize the surplus of carbon, more or less oxygen being furnished by the nitrogen-tetroxide of the nitro-naphthalines; and it follows that the higher the naphthaline has been nitrated the less of the oxidizing agent will be needed, but the greater will be the breaking power of the explosive compound.

This quality he makes use of to prepare powders of different strength in the following manner: To prepare an explosive of great breaking power for the filling of torpedoes, submarine blasting, blasting of hard rock, etc., he treats naphthaline with strong nitro-sulphuric acid (two parts sulphuric acid of 1.84 specific gravity and one part nitric acid of 1.5 specific gravity) at a temperature of 212° Fahrenheit. One hundred pounds of naphthaline require four hundred pounds of this acid. The reaction is finished in one hour. All the naphthaline is then converted into a yellow crystalline mass, which is thoroughly washed with water, dried, and pulverized. It consists mainly of di and trinitro-naphthaline, and he calls it, for this purpose, "Nitrated Naphthaline No. I."

A good blasting powder of great breaking power is obtained by thoroughly mixing the following substances: 2.18 pounds nitrated naphthaline No. I, 0.19 pound saltpeter, 0.16 pound sulphur.

To prepare an explosive of less breaking power, which is therefore better adapted for military purposes, blasting in soft and fissured rock, as gypsum, limestone, etc., he incorporates one hundred pounds of naphthaline into four hundred pounds of nitric acid of 1.40 specific gravity, leaving these substances in contact for four or five days. The naphthaline is converted into a brown crystalline mass which is washed with water, dried, and pulverized. It consists mainly of mono-nitro-naphthaline. He calls it, for this purpose, "Nitrated Naphthaline No. II."

The required explosive compound is formed by mixing thoroughly 1 pound nitrated naphthaline No. II, 3.30 pounds saltpeter, 0.51 pound sulphur.

All these substances can be pulverized, mixed, and treated in the same manner as the substances used for and in the manufacture of common blasting or gunpowder. Instead of saltpeter any other nitrate, or any chlorate, as sodium nitrate, potassium chlorate, may be used.

The powders prepared in this manner are of a yellow color. Friction or concussion will not ignite or explode them. In unconfined packages, if brought in contact with fire they will ignite and burn, but not explode. Before commencing thus to ignite, the powder will first partially melt and then burn.

To effect an explosion when desired, caps with mercury fulminate, or a small addition of gun-cotton or nitroglycerine, must be used. The heat and concussion instantaneously developed by these bodies in their explosions will explode these powders. The same may be used with or without confinement, but the powder No. II should not be used without confinement or tamping.

Their indifference to friction, concussion, and heat under all circumstances render their handling and transportation safe. Their effective labor is very great.

He claims as his invention the explosive compound composed of nitrated naphthaline, substantially as described, and an oxidizing agent prepared in the manner and substantially in the proportions and for the purposes set forth.

U. S. Letters Patent No. 397095, January 29, 1889, have been issued to Rudolf Sjöberg for a blasting compound, the chief ingredients of which are an ammoniacal salt, a hydrocarbon, and chlorate of potash, the ammoniacal salt to be either the nitrate or oxalate. If the nitrate is used, a part of it is replaced with carbonate of ammonia. The hydrocarbon used is non-nitrated, and may be partly in the liquid and partly in the solid form, or wholly solid. For the liquid hydrocarbon he preferably uses the so-called "Astral Oil," and as the solid hydrocarbon naphthalene, though other similar hydrocarbons, such as paraffine, may be used, observing only that the liquid hydrocarbon should be of such a kind as does not easily evaporate; hence benzene is not suitable.

The preparation or manufacture is as follows: The salts to be used should be finely pulverized, and must be well dried so as to be free from hygroscopic moisture. The solid hydrocarbon is first melted, and may be used alone, but is preferably mixed with the liquid hydrocarbon, being heated sufficiently for the purpose. This mixture is then divided in two unequal parts; one part, say about two-thirds, and the other part one-third of the whole. After this the ammoniacal salt, either in the form of nitrate or nitrate and carbonate, or in place of these the oxalate, is added to the larger part of the hydrocarbon mixture and carefully mixed with it by stirring. Chlorate of potash is similarly mixed by stirring with the smaller part of the hydrocarbon. The mixtures thus obtained are then mixed with each other, after which the blasting compound is ready.

The following is an example of the proper proportions for the ingredients: Fifty parts nitrate of ammonia, five parts carbonate of ammonia, ten parts liquid hydrocarbon, five parts solid hydrocarbon, and thirty parts chlorate of potash; or fifty parts oxalate of ammonia, ten parts liquid hydrocarbon, five parts solid hydrocarbon, and thirty-five parts chlorate of potash.

The proportions of the ingredients may, of course, be varied according to the purpose for which the compound is intended to be used, whether for blasting or for artillery service, etc. The following will serve as an example for such variations: Thirty to sixty parts nitrate of ammonia, one to five parts carbonate of ammonia, five to twenty parts liquid hydrocarbon, one to ten parts solid hydrocarbon, and five to thirty-five parts chlorate of potash.

It is claimed that this blasting compound cannot be exploded except within rigid enclosures, such as shells or other projectiles, or a hole bored in a rock, and then only by the use of a so-called "dynamite percussion-cap." In bored holes the percussion-cap is exploded by a fuze; but the blasting compound cannot be exploded by a fuze alone, the latter only being used to explode the percussion-cap; nor can it be exploded by concussion, such as blows against iron or stone. It will not freeze. It cannot be exploded by ramming it in a bore-hole, nor by the application of flame; but it may be ignited, in which case it will burn very slowly. It may be heated up to and above 100° C. without danger of explosion. If a fuze is applied to ignite it without the use of the percussion-cap, the fuze will burn out without igniting the powder. In order to be exploded it must be placed within a rigid enclosure, as before stated; it will not explode when placed loosely upon a rock. It will not explode under any circumstances in the open air, even if a dynamite percussion-cap is used; nor will it explode if thrown upon a red-hot iron plate, nor in a cartridge, unless the latter be placed within a rigid enclosure out of contact with the air, as when used in bombs or other projectiles, or in a rammed bore-hole, and then only by a percussion-cap ignited by a fuze or by electricity.

The letters patent claim as new:

1. "A blasting compound consisting of oxalate of ammonia, a non-nitrated hydrocarbon, as naphthalene, and chlorate of potash, substantially as set forth.

2. "A blasting compound, consisting of oxalate of ammonia, a liquid non-volatile hydrocarbon, as astral oil, a solid hydrocarbon, as naphthalene, and chlorate of potash, substantially as hereinbefore set forth."

In *Ding. Poly. Jour.* **270**, 215–223; 1888, O. Guttmann says that greater attention has of late been directed to the electrical phenomena* so often observed during the process of manufacturing gunpowder, but concerning which no safe conclusions have been arrived at, owing to the absence of the evidence of reliable observers.

The most important and also the most common occurrence is the accumulation or attraction of atmospheric electricity during storms. The buildings of explosive works, as a rule, are detached and often in elevated positions. In England it is prescribed that the lightning conductor should be fixed *on to the building itself*. In other countries it is considered sufficient to attach the lightning conductor to a high staff near to the building, and we are of opinion that the buildings in question are afforded more protection. In many cases the lightning conductor has been known to favor the discharge of electricity, and it is suggested that an explosion of a powder magazine at Salonica occurred in this way.

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* Proc. Nav. Inst. **12**, 181–182 and 423–424; 1886.

As regards the machinery in the buildings, precautions should be observed against the accumulation of atmospheric electricity as well as from other sources, more especially in the manufacture of explosives of which sulphur is a constituent. In the powder works of W. Güttler the sulphur mills are connected with the earth so as to carry off the electricity, and since this arrangement has been introduced the sulphur has never fired, it being previously a matter of constant occurrence.

In another large powder works in Germany not long since an explosion occurred in the press-house after a storm. The powder was between ebonite plates and under pressure before the commencement of the storm. When the storm had ceased, a workman released the pressure and proceeded to separate the cakes from each other. According to a statement made by him before his death, a spark 10 centimeters in length was discharged into his finger as he was in the act of lifting one of the cakes.

W. T. Reid has observed that warm air passing over nitro-cellulose generates electricity in considerable quantities. The generation of electricity has been observed in other industries during manufacturing processes, and several instances are quoted; but, according to the author, no instance has come to his knowledge which is of importance or which has caused immediate danger.

The author considers that the extensive application of rubber, ebonite, etc., to machinery used for the manufacture of explosives is somewhat hazardous. In England, for instance, the shoots of the separators and the bed-plates of the granulating mills are lined with rubber composition. This stuff has the advantage that it wears well and possesses considerable elasticity combined with great strength, etc., but under favorable conditions such a bed-plate might act as an electrophorus.

The author considers the question of the accumulation and attraction of electricity one which should receive greater attention, and observes that it should be made compulsory to connect all machinery and apparatus with the earth by properly constructed conductors.

Eng. Patent No. 1469, January 31, 1889, has been granted A. Nobel for an explosive mixture to consist preferably of charcoal, barium nitrate, and ammonium picrate, or amorphous phosphorus. The two last ingredients are added in order to counteract the slow combustion inherent to barium nitrate powders.

Otto Hehner gives a valuable paper in *Jour. Soc. Chem. Ind.* **8**, 4–9; 1889, on the "Estimation of Glycerine in Soap Lyes and Crude Glycerine," in which he describes at length the direct extraction, lead oxide, bichromate and acetin methods, and shows the two latter methods, which are so unlike in principle, agreeing in results. In connection with the direct extraction method, he states that when the solution contains more than 74 per cent of glycerine, the latter is volatilized at high temperatures, "and at temperatures beyond 100°, say 110°, as prescribed and practiced in large continental dynamite works, the loss is anything the operator may like to make it."

In discussing this paper, W. F. Reid said that all scientific analytical tests such as Mr. Hehner had described were regarded as almost useless in the dynamite factory. They used such methods as far as possible, but they mainly depended on a series of practical tests. The first step was to ascertain the amount of chlorine in the glycerine. If a sample showed much chlorine it was at once rejected, chlorine being one of the greatest sources of danger in a dynamite works. The next test was to gently warm the glycerine with sulphuric acid. If it discolored the acid much, the glycerine was rejected as being likely to cause heating in the nitrating vessel. For the detection of the fixed substances they heated the glycerine in a platinum capsule. They did not take the great precautions indicated by Mr. Hehner during this evaporation, and no doubt small portions of the mixed substances passed off with the glycerine. But they did not trouble about that. If they found an appreciable residue they rejected the glycerine, not on account of the danger, but as containing impurities in themselves useless. Of course crude glycerine was not used for nitrating purposes, as it would be dangerous. They tested that body practically by distilling it in superheated steam. That was the best test of its suitability for manufacturing purposes. There might be a certain percentage of pure glycerine in a crude glycerine, but there were also complex organic bodies present which destroyed a proportion of the glycerine in distillation and thus prevented the manufacturer from getting the yield of pure glycerine which analysis indicated as being obtainable. The final test of the pure glycerine was nitration. Nitration was done in the ordinary way and with the usual acids used in the factory. The practical yield was always lower than by the refined methods described by Mr. Hehner, because of the solubility of the nitroglycerine in the acids which were used to nitrate it. They had tried to precipitate the nitroglycerine from the acids by dilution with water, but had found it to be also to some extent soluble in the acid water, so that only a small proportion of the dissolved nitroglycerine could be recovered in that way. The best method was to freeze the solution. He was quite aware that the tests he had described could not be considered accurate quantitative methods, but they were tests which enabled manufacturers to know what results to expect in actual working, those results being always considerably below the theoretical yield of pure glycerine; roughly speaking, he would say at least 5 per cent below it.

It has been observed some time since that when mixtures of hydrogen and oxygen, in the proportion of 2 to 1, are exploded in a very long tube, an explosive residue remains unburnt even when the oxygen is in excess. This "Imperfect Combustion in Gaseous Explosions" has been studied by H. B. Dixon and H. W. Smith, and the nature of the residual gas, with varying compositions for the original mixtures, determined. The tube used was 100 m. long and 9 mm. in diameter, with a capacity of 8100 cm^3. and an internal surface of 29,000 cm^2. With three mixtures—A, in which hydrogen was in slight excess, and B and C, in which oxygen was in excess—the following mean results were obtained:

	A.	B.	C.
Average residue,	150 cm^3.	160 cm^3.	220 cm^3.
H	54.3 p. c.	29.5 p. c.	20.5 p. c.
CO	...	5.1	5.8
O	19.4	38.1	32.7
N	26.3	27.3	41.0

Other experiments showed that the extent of the surface of vessel or tube employed does not exert any great influence on the explosion of the gases. Similar results were obtained with mixtures of carbon monoxide and oxygen. These results appear to confirm the observations of Mallard and Le Chatelier that the cooling in this method of combustion is more rapid than in ordinary combustion, and they also bear on Berthelot's theory of the mode of propagation of explosion waves.—(*Chemical News* **59**, 65–66; 1889.)

The term catalysis was first applied by Berzelius, *Ann. Chim. Phys.* **37**, 66, to the power shown by certain substances of causing decomposition or other chemical changes in other substances without being themselves affected.

Dulong and Thénard have shown, *Ann. Phys. Chem.* **76,** 81, that all metals and some earths can determine chemical union between oxygen and hydrogen at temperatures below the boiling point of mercury, and in the case of platinum, palladium, rhodium, and iridium, at ordinary temperatures. Faraday has shown, *Ann. Phys. Chem.* **33**, 149, that the action of platinum on oxyhydrogen gas occurs at ordinary temperatures only when the surface of the metal is perfectly clean.

Henry, *Phil. Mag.* [3] **6,** 354, and Turner, *Annalen* **2,** 210, have shown that copper and iron turnings, zinc-foil and wood-carbon have the same effect on oxyhydrogen gas, but only at temperatures not far below the boiling point of mercury; and Loew, *J. pr. Chem.* [2] **11,** 372, has shown that glass begins to act in the same way at about the same temperature.

Berthelot, *J. Chem. Soc.*, Abstr., 1022; 1882, pointed out the connection existing between catalytic action and occlusion of hydrogen, and the following paper contains an account of an extensive series of experiments directed to the further elucidation of the subject. In studying the "Catalytic Action of Metals on Oxyhydrogen Gas and the Occlusion of Hydrogen," *Ann. Phys. Chem.* **35** [2], 791–810; 1888, A. Berliner arrives at the conclusion that these catalytic actions are invariably due to the occlusion of hydrogen, which, when occluded, always seems to act in the same way as when in the nascent state, as Graham, *Phil. Mag.* [4] **32,** 503, showed conclusively in the case of palladium. The fact that when the metallic surface is not clean, catalysis still takes place at high temperatures, is attributed by the author to the partial removal of the film of impurity when the temperature is sufficiently increased; this is in accordance with Graham's observation that the largest amount of gas was occluded when the metal was first strongly heated and then allowed to cool in the gas forming the subject of experiment.

The "Decomposition of Potassium Chlorate by heat in the presence of Manganese Peroxide," which takes place with great readiness, has sometimes been referred to as due to the catalytic action of the oxide. Investigation of the phenomena by H. McLeod, *Jour. Chem. Soc.* **55,** 184–199; 1889, and by W. R. Hodgkinson and F. K. S. Lowndes, *Chem. News* **58,** 309; 1888; **59,** 63–64; 1889, of the action of various metallic oxides, shows that the process is one of considerable complexity, but is purely chemical, and that the manganese oxide is repeatedly oxidized and reduced with the intermediate formation of potassium manganate and permanganate.

It has long since been observed that when water is electrolyzed by means of an alternate current, the mixed gases in the voltameter sooner or later explode. De la Rive, who noticed the phenomenon, attributed it to the catalytic action of the platinum black which he saw formed on his platinum electrodes. Bertin attributed it to the polarization of the electrodes.

In studying the mechanism of electrolysis by means of alternating currents, G. Maneuvrier and J. Chappuis found these explosions a constant source of trouble, and so they carefully investigated the phenomenon with a view to its prevention. Their results, given in the *Comptes rend.* **107,** 92; 1888, under the title "Spontaneous Explosions occurring during the Electrolysis of Acidulated Water by Alternating Currents," show conclusively that the explosion of the mixed gases is brought about by the platinum electrodes becoming heated to such a point as to determine the recombination of the dissociated elements. This heating is due to three causes, all of which depend ultimately on the gradual descent of the level of the electrolyte, in the voltameter, thus having more and more of the electrodes in contact with the gases. Firstly, owing to the smaller surface of the electrodes the current density is increased; secondly, the surface resistance is increased; thirdly, the cooling action of the electrolyte is decreased. It becomes, therefore, easy to prevent the explosion by taking due precautions to guard against the heating of the electrodes.

The *Comptes rend.* **107,** 96–99; 1888, contains a paper by Mallard and Le Chatelier, "On the Method of Blasting in Fiery Mines."

The results of the researches of Berthelot and of Sarrau and Vieille enable us to determine with considerable precision the properties of the explosive substances. Up to the present, however, they have considered chiefly the mechanical effects of these bodies, passing by, as a secondary consideration, the temperature of the gases at the moment of detonation and before they have had time to cool even partially.

This temperature can be calculated by applying to the gaseous products of the reaction, the values, increasing with the temperature, for the specific heats of the gases; such have been obtained by these authors in their former experiments.*

One can verify the accuracy of the temperatures calculated in this way by comparing them with the observations made by different experimenters, and notably those of Sarrau and Vieille on the pressures developed in closed vessels by detonating explosives.

In effect, when the temperature is high and the volume of the gas is not too small, we may calculate this pressure P by the formula

$$P = \frac{f - \Delta}{1 - \alpha\Delta}, \qquad (1)$$

which is deduced from Clausius' formula, in which

$$f = \frac{1.0333 v_0 T}{273 \omega} \text{ and } \alpha = \frac{u v_0}{\omega}, \qquad (2)$$

where

Δ = density of loading $= \frac{\omega}{V}$.

ω = weight of explosive in kilograms.

V = volume in liters of vessel in which detonation takes place.

P = pressure in kilos. per cm². of vessel in which detonation takes place.

T = temperature of detonation in absolute degrees.

v_0 = volume of gases produced at 0° and 76 cm.

u = a coefficient called the *covolume*.†

The authors have proved that the experiments of Sarrau and Vieille on the pressures developed by cellulose endecanitrate, ammonium nitrate, and a mixture of cellulose endecanitrate 60 parts and ammonium nitrate 40 parts, verify, very exactly, expression (1), and this demonstrates that the law of the covolume applies even at temperatures approaching 3000° and pressures of more than 7000 atmospheres. From the lowest of these temperatures and pressures to the most considerable it appears, at least for the gases which we encounter in the products of the detonation of explosives, *as if the gaseous molecules had an invariable volume which is the same for all, and which is very nearly equal to the one-thousandth of the gaseous volume at zero and under atmospheric pressure.*

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* Comptes rend. 1882, and Annal. Mines, 1883.

† The value of this coefficient has been calculated for different gases by Sarrau from the experiment of Armagat, but the authors believe that the value should be the same, or very nearly so, for all gases, and they have taken it as equal to 0.001.

They have shown further for those explosives in which the ratio of the perfect gases to the carbon dioxide and water vapor is relatively small (such as dynamite and the mixture of gun-cotton and ammonium nitrate), that the agreement between f observed and f calculated from the temperature of combustion is very close when their own data for the specific heats of CO_2 and H_2O is used. The difference in the values is not more than three per cent.

When the perfect gases are present in considerable quantity, as in gun-cotton and picric acid, the difference reaches to ten per cent, and will be much greater if it is held that the molecular specific heat of perfect gases is constant at all temperatures. To represent the results of the experiments it is necessary to admit that the coefficient b in the formula $c = a + bt$, which was taken for perfect gases as equal to 0.0006, becomes at least 0.0013. The increase of the specific heats of the perfect gases with the temperature which is deduced from their experiments is confirmed most completely by the observations of Sarrau and Vieille on the pressures developed by explosives detonated in closed vessels.

The commission on explosives which has recently been studying the important question of blasting in fiery mines, has arrived at results which strongly confirm the preceding deductions. This commission has proved by numerous experiments that explosives, when detonated in the midst of fire-damp mixtures, cannot inflame them except when the temperature of detonation exceeds 2200°. The authors have previously found that the point of ignition of these mixtures is 650°, but at the same time they are inflamed slowly. It is probably owing to this slowness of inflammation, combined with the expansion and consequent extremely rapid cooling which the gaseous products of the detonation undergo, that the great difference between 2200° and 650° is due.

The commission has thus been able to prepare mixtures of explosives which were incapable of igniting fire-damp mixtures when detonated unconfined in their midst. To determine what composition such mixtures should have, it was found sufficient to assure one's self that their temperature of detonation, when calculated with Berthelot's thermo-chemical data and Mallard and Le Chatelier's value for the specific heats, was below 2200°.

It is by such means that the commission has proved by numerous experiments that mixtures of dynamite with equal weights of crystallized sodium carbonate, sodium sulphate with 10 molecules of water, ammonium alum and ammonium chloride, will not inflame fire-damp mixtures in the midst of which they are detonated. They produce the same effect on dynamite detonated in coal-dust mixtures.

The mixtures formed on adding ammonium nitrate to nitroglycerine or to gun-cotton are particularly advantageous because the nitrate itself acts as a detonant, while it lowers the temperature of the detonation to nearly its own detonation temperature, which is 1130°, whilst that of dynamite is 2940°, that of nitroglycerine is 3170° and that of cellulose endecanitrate is 2636°.

The commission finds that mixtures of dynamite or nitroglycerine with 80 parts of ammonium nitrate, and naturally mixtures which are richer in nitrate, do not ignite the marsh gas mixtures, and that it is the same with mixtures containing in 100 parts 20 parts or less of a cellulose nitrate whose nitrogen dioxide contents is less than 193 cm^3.

Cartridges made of different mixtures according to the general principles indicated here have been submitted to numerous trials, and they are to be tried on a large scale in the mines, where it is hoped to realize great safety.

U. S. Letters Patent No. 393794, December 4, 1888, have been granted George French for a "Method of Blasting," to be used in coal mines and similar places, to prevent firing the gases in the mine when the explosion occurs, and which consists in surrounding the charge in the bore-hole with a fire-extinguishing powder composed of sawdust wet with the following mixture: Alum, 5.1 per cent; sal ammoniac, 1.7 per cent; salt, 10.2 per cent; water, 83.0 per cent.

This solution is incorporated with the sawdust in about the proportions of two parts of the former to one of the latter, and three-fourths of one per cent of black lead is added. The powder is stored for use in the damp state, so that it binds together when exposed to pressure and is thus easily consolidated around the blasting charge. It is held that a great advantage results from employing a powdered composition in place of water or jelly-like substances, since the powder is separated more readily and is more completely distributed, while it may be rammed around the blasting charge without the interposition of waterproof linings and the like.

The claim is for "the method of blasting consisting in making a bore-hole, inserting the blasting charge therein, ramming around the blasting charge sawdust or like absorbent powder saturated with a solution of alum, salt and sal-ammoniac, or an equivalent salt solution, and then firing the charge in the bore-hole when thus surrounded with the said powder."

The *Ber. Berl.* **22,** 18-23; 1889, contains the results of L. Meyer's studies of the process of " Nitration." He finds that the quantity of nitrobenzene formed in a given time by the action of a given volume of nitric acid on benzene is greater the less the quantity of benzene present; for example, 100 mols. of nitric acid and 100 mols. of benzene yield 17 mols. of nitrobenzene in 15 minutes at 3°; but when 300 mols. of benzene are employed, the quantity of nitrobenzene produced is 10.02, and when 700 mols. of benzene are used, only 3.6 mols. of nitrobenzene are produced in the same time under exactly the same conditions. The results are similar when small quantities of benzene mixed with a constant quantity of nitrobenzene are treated with a constant quantity of nitric acid. A mixture of 100 mols. of nitric acid and 5 mols. of benzene diluted with 100 mols. of nitrobenzene yielded 4.4 mols. of nitrobenzene in 15 minutes at 3°; as the quantity of benzene was gradually increased from 5 to 100 mols., the quantity of nitrobenzene formed in the same time and under the same conditions gradually decreased from 4.4 to 2.2 mols.

When a mixture of 100 mols. of benzene and 100 mols. of nitrobenzene is treated with quantities of nitric acid varying from 50 to 450 mols., the quantity of nitrobenzene produced in 15 minutes at 3° is proportional to the square of the quantity of the acid employed. The quantity of acid decomposed is almost proportional to the quantity added, the increase being about 2.55 per cent on the average for each additional 50 mols. of acid. The quantity of nitrobenzene produced in 15 minutes at 3° is expressed very closely by the formula,

$N = 5.1(A/B)^2 - 2.9A/B$, where A is the number of molecules of acid, and B the number of molecules of benzene in the mixture.

Nitrobenzene retards the reaction between nitric acid and benzene far more than benzene does, and even to a greater extent than an equivalent quantity of water, but less than an equal volume of water. As soon as the volume of water produced becomes equal to that of the anhydrous acid present, the reaction ceases, so that at least 2 mols. of acid are required to nitrate 1 mol. of benzene, unless sulphuric acid is also added. If the proper quantity of anhydrous acid is employed in nitrating benzene, equilibrium is established very soon, even in the cold; but if the acid is not quite anhydrous, or if excess of benzene or nitrobenzene is present, hours or even days are required to complete the reaction, and in any case the nitration, which is most rapid at first, gradually decreases. For example, with a mixture of equal molecules of nitric acid, benzene and nitrobenzene at the average temperature of 18°, the reaction was not finished until after 71 hours' time; 50 per cent of the benzene had by this time changed, but even then there was a slight subsequent reaction.

A table is given showing the quantity of acid decomposed after various lengths of time, when quantities of benzene varying from 25 to 150 molecules are added to a mixture of 100 molecules of nitric acid and 100 molecules of nitrobenzene. The table shows that in the experiments with 25 molecules of benzene, the conversion into nitrobenzene is complete in half an hour, and that then the formation of dinitrobenzene commenced. In the other experiments the reaction proceeded at first the more quickly the smaller the quantity of benzene present, this difference gradually becoming less and less the nearer the process reached the point at which half the acid is decomposed.

In their investigations upon the "Constitution of the Jute Fiber-substance" or lignocellulose (*J. Chem. Soc.* **55**, 199–213; 1889), Cross and Bevan have, among other reactions, noted the effect of the time of exposure on the products obtained by nitration.

In the first experiment cited they used raw jute fiber and a nitrating acid formed of equal volumes of nitric acid (sp. gr. 1.43) and sulphuric acid (sp. gr. 1.8). The temperature being 18°, they obtained the following results:

I. Duration of exposure.	Yield per 100 parts of fiber.	
1 minute.	125.2	
2 "	129.2	
3 "	140.0	
4 "	149.0	
15 "	146.0	secondary actions with conversion into soluble products.
16 hours.	131.0	

In three other experiments the nitrating mixture was: II. As in I; III. Equal volumes of nitric acid 1.5 sp. gr., and sulphuric acid 1.8 sp. gr.; IV. Nitric acid sp. gr. 1.5, one volume, and fuming sulphuric acid 0.75 volume. Besides this, two varieties of fiber were used: A. Raw fiber such as was used in I; and B. the modification resulting from the action of hot dilute hydrochloric acid upon this fiber. The duration of exposure in all cases was 30 minutes at 18°. The yield of nitrate per 100 parts of dry fiber was:

	II.	III.	IV.
A	144.4	153.3	154.4
B	143.8	152.8	152.7

A reaction according to the equation $C_{12}H_{18}O_9 + 3HNO_3 = 3H_2O + C_{12}H_{15}O_6(NO_3)_3$, is equivalent to a gain in weight of 44 per cent; the conversion into the titranitrate, 58 per cent. The formation of the latter appears, therefore, to be the limit of nitration of the jute fiber; in other words, if we represent the lignocellulose by a C_{12} formula, it will contain four alcoholic OH-groups, or two less than cellulose similarly represented.

To confirm the composition of these products and the equations above given, the specimen IV A was analyzed by Eder's method (*Ber.* **13**, 109) with the following result:

0.453 gram gave 82 cm^3. NO at 19° and 770 mm.; whence $N = 10.5$ per cent. Calc. $C_{12}H_{15}O_6(NO_3)_3$, $N = 9.5$ per cent; $C_{12}H_{14}O_6(NO_3)_4$, $N = 11.5$ per cent.

These nitrates resemble those of cellulose in all essential points. There is no evidence of any resolution of the molecule attending its combination with the acid radicle; the product is a nitrate of the lignocellulose, which again manifests itself as a chemical individual.

Patent 4310, March 20, 1888, has been granted in England to E. Turpin for an improved smokeless powder for firearms, which is prepared by dissolving gun-cotton more or less nitrated in any solvent most suited to the kind of gun-cotton employed, *e. g.* "nitrobenzene and other nitro-bodies of the aromatic series, aniline, aldehydes, amido-compounds of various kinds, acetone, sulphuric, nitric, acetic, and other ethers." Also "ammonia in solution in sulphuric or other ether, acetone in solution in sulphuric or other ethers or mixtures of ethers are suitable for dissolving gun-cotton more or less nitrated."

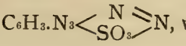
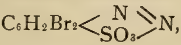
The resulting paste is spread upon plates or trays with raised edges and allowed to dry. When sufficiently dry the sheets are rolled out to the desired thickness, and subsequently cut crosswise by suitable machinery, in order to form small cubes. The rapidity of combustion of the powder is retarded by the addition of camphor, nitrobenzene, nitrotoluene, paraffine, etc. By varying the proportions of the ingredients above named, " powders may be obtained adapted to suit all requirements."

A. Nobel has been granted Eng. Pat. 1470, Jan. 31, 1888, for a safety fuze, which is made of a celluloidal substance in the following manner: To 100 parts (by weight) of nitroglycerol 15 to 20 parts of camphor are added, and the solution thus obtained is thickened by dissolving 6 parts of nitrated pulped cotton in it. Seventy parts of potassium chlorate, 25 parts of potassium ferrocyanide, and 44 parts of soluble nitrate are then added, and the whole thoroughly incorporated to produce a substance of the consistency of soft India rubber and easily workable into thread. The advantages claimed for this fuze are absolute continuity, imperviousness to moisture, and absence of smoke when ignited.

English Patent 15771, Nov. 17, 1887, has been granted F. Crane for improvements in and connected with varnishes, which consist in using a solution of shellac in combination with a solution of pyroxylin in a practically non-hygroscopic menstruum miscible with the shellac solution.

English Patent No. 487, Jan. 12, 1888, has been granted A. Orr for improvements in forming solutions and compounds of nitrocellulose. The solvent employed is "a chlor-acetate of chlor-amyl," prepared by the action of chlorine on fusel oil "and other chemicals," and may be diluted with from 2 to 5 parts of fusel oil. A solution of nitrocellulose in this solvent mixed with castor oil and "wood pitch" is said to give, by suitable treatment, a very good insulating material.

In a paper entitled "An Improvement in the Manufacture of Chlorate of Potash" (*Jour. Soc. Chem. Ind.* 8, 168–173; 1889) M. J. Hamill describes in detail, with illustrations and tables, the method he employs of refrigerating the mother-liquors so that the yield is increased about one-seventh.

In his study of the " Hydrazine Sulphonic Acids and the Triazo-Compounds," *Ber. Berl. Chem. Ges.* **21**, 3409-3423; 1888, H. Limpricht has obtained the following explosive compounds: Barium metatriazobenzenesulphonate, $Ba(C_6H_4.N_3.SO_3)_2$, which crystallizes in slender, colorless needles, and explodes when heated to 130°; potassium triazonitrobenzenesulphonate, $K.C_6H_3.N_3.NO_2.SO_3$, which crystallizes in light brown plates, is very unstable, is readily soluble in hot water, and explodes when heated to 130°; diazotriazobenzenesulphonic acid,  $C_6H_3.N_3<\substack{N\\SO_3}>N$, which is obtained in orange-red crystals that turn dark blue on exposure to the air, and explode violently both through percussion or heat; diazodibrombenzenesulphonic acid,  $C_6H_2Br_2<\substack{N\\SO_3}>N$, obtained in yellow crystals, which are very sparingly soluble in cold water, are decomposed by boiling water, and explode violently when heated; barium triazodibrombenzenesulphonate, $Ba(C_6H_2.Br_2N_3.SO_3)_2$, crystallizing in pale red plates which are sparingly soluble in cold water; hydrazinebenzenedisulphonic acid, $NH_2(C_6H_3.\dot{N}H.N.SO_3H.OH)_2$, crystallizing in fine, lustrous yellow rhombs, insoluble in most of the usual solvents; and barium triazobenzenedisulphonate, $Br(C_6H_3.NH.N_2.SO_3.OH)_2.3H_2O$, which crystallizes in yellowish plates that decompose slowly at ordinary temperatures.

Among other "Aromatic Lead Compounds," A. Polis has obtained a basic lead ditolylnitrate $(HO.Pb(C_7H_7)_2NO_3)$ in the form of a white amorphous powder which explodes slightly when heated. —(*Ber. Berl.* **21**, 3424-3428; 1888.)

Eng. Pat. 11537, August 24, 1887, was granted O. Bowen, A. S. Tomkins and J. Cobeldick, for improvements in the manufacture of charcoal, the object of the invention being to produce a charcoal rich in hydrogen and suitable for the manufacture of gunpowder. For this purpose wood or suitable carbonaceous matter is subjected to a heated current of air mixed with hydrogen. The furnace employed has been described in Eng. Patents 509 of 1881 and 1457 of 1886.

German Patent 44078, December 19, 1887, has been granted to H. Güttler for further improvements in his charcoal furnace, the wood being introduced in the form of pulp. The improved apparatus cannot be described in the absence of drawings, but it seems to be an important addition to this special branch of powder manufacturing.—(*Ding. poly. Jour.* **270**, 215; 1888.)

The *Moniteur de la Photographie* of Paris calls attention to a dangerous explosion of ether which occurred while this liquid was being carefully evaporated in a platinum dish, after having served for extracting grease. The ether was very old, having been kept in a stock bottle for many years, and probably exposed to light. It contained no less than five per cent of hydrogen peroxide, to which the explosion is ascribed, and a little acetic and formic acids.—(*Pop. Sci. News* **22**, 38; 1888.)

Science **13**, 152; 1889, copies from the Ottawa *Journal* a notice of a rather unique phenomenon, known as a "Sawdust Explosion," which is a breaking up or bursting through of the ice that occasionally occurs on the Ottawa river, Canada, and is supposed to be due to the sudden liberation of immense quantities of marsh gas which has been generated by the sawdust that has been thrown from the sawmills at this place, and is accumulated in the bed of the river. The gas is said not to be ignited. No proof of the existence of the gas other than the bursting of the ice is given.

Mr. Wolcott C. Foster contributes to the *Eng. News* **21**, 29; January 21, 1889, "A Classification of Explosives," which he offers in lieu of those in use. The scheme is, however, faulty in many particulars and ought not to be followed. Among others we may note that although Class VII is styled "Fulminates," Class VIII is styled "Chemical Compounds," nitrogen iodide and panclastite (*sic*) being given as examples. Again, for Class IV "Nitro Powders," we have the organic nitrates, mannitose and saccharose nitrates, as examples, while no provision is made for the large number of nitro-substitution compounds which are now coming into prominence.

A "Catechism of Explosives," by Charles E. Munroe, which is intended for use in the instruction of seamen-gunners, has recently been issued from the press of the Torpedo Station.

Ernst and Korn, Berlin, 1888, announce "Das Wesen und die Behandlung von brisanten Sprengstoffen."

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

DOMESTIC STEELS FOR NAVAL PURPOSES.

By Lieutenant-Commander J. G. Eaton, U. S. N.

The adoption of steel in place of iron on board our men-of-war is now an accomplished fact. The line officer finds his hulls, rigging, masts, guns and carriages, shields and armor, all of steel. The engineer deals with the same metal in boilers, engines, shafting, and propeller. Steel has usurped the place of iron, and wherever increased strength is needed, saving of weight a factor, or reduction of section an object, steel is now used.

Steel is purely and simply an iron in which are dissolved carbides, sulphides and phosphides of iron. To these may be added metalloids such as manganese, aluminium, and chromium, or through the original ores may come impurities, notably arsenic, cobalt, antimony, copper and silver. Practically speaking, steel is an alloy, principally iron, which is both fusible and weldable. In these two characteristics it unites the qualities of cast and wrought irons. By varying the carbon we can produce a steel softer than soft malleable iron, or harder than hard cast iron. It can be rolled in sheets which may be folded like paper, or cogged into rods which may be tied into square knots without crack or fracture. On the other hand, steels are made which will scratch glass like a diamond, or crush the hardest rock without scarring its surface. Between these widely separated qualities it appears in innumerable conditions which fit it for almost every conceivable purpose, and this younger son of Vulcan, inheriting all the sterling qualities of his old father Iron, but spurning the slag and oxidations which clogged the veins of his dusky sire, laughs at burdens which bent the ancestral back.

In order to gain a clear knowledge of the material with which we are to deal, it is proper that we should study the various methods by which steel is produced, and judge whether any particular process is defective, or its application difficult and its results uncertain. In entering upon the methods now in use, I feel that I am treading a path well worn, and if the reader finds familiar landmarks, recognized long years ago, I tender my sympathy. It is essential to a clear understanding of the subject to pursue some rather tedious details.

Although crucible steels play some part in our naval ships, we can safely dispense with any discussion of its merits. Its excellences are acknowledged and its limitations recognized. Although Krupp has united the charges of a thousand crucibles in a single cast, we are not likely to see this feat repeated. We may, therefore, narrow our observations to steels produced either by chemically evolved heat, as in the Bessemer and Clapp-Griffith converters, or steels melted by fuel gas, as in the open-hearth furnaces. In the Bessemer no extraneous heat is applied to the molten iron, the rise in temperature being effected by the active combustion of the manganese, carbon, and silicon in the iron itself. In an open-hearth furnace these same elements do augment the temperature, but the melter relies upon fuel gas as the heating medium. As an illustration of this point I cite a heat of thirty tons of low carbon steel nearly ready to teem, which, through the settling of the furnace wall, set solid in the bowl. The gas was turned off, the furnace wall rebuilt, the gas (natural gas) turned on again, and the entire mass re-melted and teemed within thirty hours from the time the gas was ignited.

THE BESSEMER PROCESS.

The Bessemer process, named for Sir Henry Bessemer, its inventor, antedates the Siemen-Martin open-hearth furnace, and marked the first great step towards the cheapening of steels. The salient feature of Bessemer production is the rapid reduction by combustion of the silicon and carbon in molten iron by means of a cold blast under pressure. A ladle of molten iron, containing from one to fifteen tons, is poured into an egg-shaped, brick-lined converter, which swings on trunnions and is open at the upper end. Through this charge, by means of tuyères in the bottom, is forced atmospheric air under pressures of from five to twenty-five pounds per square inch. The temperature rises rapidly by the oxidation of the carbon and silicon in the blow. The heat developed rises to about 3500° F. The blast is continued till the metal is sufficiently blown, as evidenced by the sudden drop and change of color in the flame. The blast is then turned off, the converter turned on its trunnions, and the "blow" poured into ladles, a proper quantity of ferro-manganese being added to effect re-carburization. The whole operation requires from ten to twenty minutes, and three blows to an hour is not uncommon practice. Practically, as Sir Henry Bessemer said, "the iron is boiled without the application of heat." The rise in temperature from 1800° F. to 3500° F. is due solely to the combustion of the elements in the molten iron itself.

In theory the Bessemer should produce a perfect steel. In practice, as good samples can be made as by any other process. But they are samples, obtained by careful selection of charging material and unusual supervision of the blow. The facts that a few seconds of overblow will introduce burnt irons which ruin cohesion in the product, or that underblown metal is practically useless, preclude the practicability of always securing a uniform, trustworthy, and homogeneous steel. The silicon should go with the carbon, and the instant it is gone the iron itself burns. In short, the Bessemer process is one of extreme delicacy. The blower must always go to the verge of burning his metal, else in avoiding this Scylla he risks the Charybdis of the underblown metal.

Underblown metal is hard, brittle, and unreliable, with small elongation, due to an excess of manganese, there not being a sufficient amount of oxygen to take up the manganese introduced in recarburization.

By the acid Bessemer process, the carbon, manganese, and silicon are consumed, a small percentage of carbon remaining. The sulphur and phosphorus are not eliminated. All of these two impurities which entered in the charge come out in the ingot with increased percentages, due to the loss of iron by blowing.

The Bessemer process is more economical than the open-hearth. Its advocates claim for it the merits of reliability and uniformity, but whilst as good steel *can* be produced by this method as is needed, the very nature of the process carries uncertainty with it. The high temperature at which it is teemed is favorable to the dissociation of the metalloids in cooling, and in large ingots this becomes a very serious fault. The castings attempted for the Maine by this process were not successful, and they were assigned to an open-hearth manufacturer.

The Clapp-Griffith process is so nearly allied to the Bessemer as to need no special description. The main characteristic consists in introducing the blast near the surface, and not at the bottom, of the charge, as in the ordinary Bessemer. Its products of soft steels are good and its metals sufficiently uniform.

The best results with blown metals are obtained from small converters. It is a question whether the success which has attended the Clapp-Griffith is not due more to this fact than to all the special features. In small converters there is more air blown in proportion to the amount of iron. This would produce a carbon dioxide which generates much more heat than the carbon monoxide produced in the large Bessemers. The slag-hole in the Clapp-Griffith converter can have only the slightest beneficial effect. The fact that the converter is stationary is of advantage.

In writing thus regarding Bessemer steels I desire to make it clear that sound, trustworthy steels can be made, and undoubtedly have been made, by the thousands of tons by this process. I have myself witnessed a hundred consecutive heats from the Homestead converters that showed a surprising uniformity in chemical composition and physical properties. The point I desire to emphasize is that the Bessemer process is one of extreme delicacy, and that Bessemer steel has not been made, and probably cannot be made, with the regular uniformity of open-hearth steel.

Steel can be made badly by any process, but by adhering to a process where the liability of error is reduced to a minimum, we are taking the simplest precaution possible.

OPEN-HEARTH PROCESS.

The acid open-hearth furnace, whether for ore and scrap, or pig and scrap, consists essentially of a huge brick bowl, generally oval in contour, surrounded by walls and covered with an arched roof, all of refractory silica (acid) brick. Through doors there are charged into this bowl first pig-iron, then acid-washed metals and scrap, or simply scrap, such as plate shape and shaving scrap of steel, crop ends of ingots, old rails, etc. The steel scrap is placed on top, as it is the most refractory. Fuel gas is admitted through large entry ports, with heated air, and deflected downward, in order that the flame may play upon the charge. The escape port for the products of combustion is diametrically opposite. The reversal of the current every fifteen minutes serves to heat the regenerative passages through which the air is admitted. The air enters the furnace at about 1000° F. From four to seven hours are required to fully melt the charge. Oxidation is produced by oxide of iron, and there is no difficulty about the silicon, as it is burned before the carbon.

It will be seen that the process is a slow one, taking hours to accomplish what the converter does in minutes. The heat is always under control, and with only one element, carbon, to watch, the melter has entire control of his process.

The bath being formed by the melting of the charge, ore is added. Violent ebullition at once ensues; the carbon in the ore, set free by the intense heat, flying off almost explosively. The melt seethes and surges under the tremendous chemical reactions. The temperature, already glowing white, rises hundreds of degrees. With long hickory poles the melter thoroughly rabbles every part of the heat, searching for refractory lumps on the bottom. The slag rises to the surface, and as the temperature lowers and the boil subsides, the top of the "heat" is seen covered with floating scum. The critical period of open-hearth practice is during and at the end of the boil. Owing to the sudden increase of heat the iron is apt to burn, producing low oxides, which, re-appearing in the finished steels, prevent homogeneous weldings and cause snakes. Any impurity in the flame of the fuel gas is at this time readily absorbed by the bubbling steel.

Specimens are now taken, rapidly cooled, broken, and the carbon point determined by the color of the fracture. When the carbon has been reduced to .06 of one per centum, ferro-manganese is added. The carbon point desired is obtained by the proportion added, and the manganese serves its purpose by combining with the oxides of iron and purging the "heat." The temperature is now lowered to the teeming point, and the "heat" run into ladle and thence poured into ingots at as low a degree of heat as is possible without chilling. The time from the beginning of the charging to the tapping, has taken from seven to eleven hours. From beginning to end the temperature has been under the control of the melter. If too fierce a flame has oxidized the iron, the melter is to blame. The process allows ample time, and if there is any burnt metal in the ingot there has been either gross carelessness or improper material charged.

With the ordinary open-hearth, as with the Bessemer process, all the phosphorus and sulphur in the original charges reappear in the ingot, with increased percentages due to loss of iron. Neither process has aided us in eliminating these active enemies of good steel.

The points to be noted in the ordinary open-hearth process are:

1. Careful analysis, and by means of this analysis the careful adjustment of the weights of each class of material charged.

2. The interval of time allowed for the escape of injurious gases (practically all gases are injurious to the product).

3. Facilitating the escape of these gases by thorough rabbling, assisting each portion of the "heat" to part readily with gases held mechanically.*

4. The promotion of homogeneity by the long interval of time permitting a thorough mix.

5. The fact that by the turn of a lever the melter has control of his temperature.†

6. The oxidizing flame is in contact with only the surface of the "heat," and this surface is protected by floating slag.‡

7. And all-important, the melter can judge by tests of the character of his "heat" before teeming.

In the "Proceedings," Vol. XIV, No. 4, I pointed out the evils attendant upon high sulphur and phosphorus. I will add here another most serious injury caused by high phosphorus in ship plate, viz., increasing acid corrosion.

M. Savioz, chemist at St. Nazaire, exposed steels of various conditions to acid waters, and carefully observed the loss of weights. Without detailing at length the results, let me say that he found that "a high proportion of phosphorus exerted a decidedly deleterious influence on the behavior of the metal." This appears to be a point of great importance to men-of-war, which are frequently exposed for months to waters permeated with acid gases. I need only mention the "Callao painter" as an instance to those familiar with the West Coast.

Our American ores are reasonably free from sulphur. To obtain low phosphorus steels we have been forced to qualify our charges with foreign ores, Spanish, African, and Cuban, but the basic open-hearth process, which has passed its experimental stage in producing domestic steels from domestic ores, will effectually rid us of those *bêtes noirs*, sulphur and phosphorus. The basic Bessemer process accomplishes the same results in blown metals. It has doubtless produced good steels, but, like the ordinary Bessemer, it is subject to irregularities, and as it undertakes the elimination of three elements, viz., phosphorus, silicon, and carbon, whilst the ordinary Bessemer deals only with the two latter, it is more intricate and more difficult of successful accomplishment. Wretched failures have occurred in many thousands of tons of German and British basic Bessemer plates and shapes. As before, the theory is perfect, but regular practice is unreliable.

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* In some Bessemer works the steel is thoroughly rabbled in the converter after blowing, and the "blow" is allowed to cool materially before pouring.

† At excessive temperatures in Bessemer or open-hearth practice, not alone is burnt iron produced, permitting cement carbon to escape, but at these temperatures some gases will penetrate the whole charge, oxidizing irons which cannot be regenerated. An open-hearth furnace heated only by radiation would produce best results.

‡ In a Bessemer converter the flame permeates all parts of the "blow."

The principle upon which basic Bessemer is based is identical with basic open-hearth. I will confine myself, therefore, to a description of the latter only.

BASIC OPEN-HEARTH.

In form, application of heat, method of charging, and general management, a basic furnace is identical with an acid furnace, the essential points of difference being in the material composing the bowls and side-walls, and the artificial introduction of bases for reduction of acids in the steels. The bases thus used are, primarily, lime and magnesia, and, secondarily, manganous oxide formed in the heat itself from the manganese ore.

In a basic furnace the bowl which holds the melt is lined with calcined dolomite, and its surface afterwards fettled with the same mixed with tar. This is in lieu of the sand used in the acid furnaces. The side-walls, as far as it is possible for the metal to reach during the boil, are similarly lined. The remainder of the furnace is of acid (silica) brick. Peculiarities of walls, roofs, bowls, etc., exist in basic furnaces, but they are matters of practice and in nowise affect the principle.

Charging, melting, and teeming.—The basic furnace is thus charged: a heat having been run, and the bottom patched with calcined dolomite and tar, limestone rock is placed first on the floor of the furnace. Care is exercised that the limestone is spread evenly, completely covering the bottom. On top of the limestone is charged manganese ore, about 400 pounds of ore to 2500 pounds of limestone serving to flux about seventeen tons of steel. Upon the ore will next be charged pig-iron, and last of all, Bessemer crop ends, rail ends, and scrap generally. The furnace is hot when charged. Four hours at the utmost serve for the complete melting of the charge. The melted limestone is rising continuously through the bath, keeping up a more or less violent ebullition. The phosphorus mostly disappears in the early part of the " heat," and by the time that the carbon is gone the "heat" is dephosphorized, the phosphorus, as phosphoric acid (P_2O_5), being taken up by the bases. The manganese ore assists in desiliconizing and decarburizing the pig, forming a manganous oxide MnO, which is itself a strong base, greatly increasing the fluidity of the floating slag. Apart from the strong affinities of phosphoric and sulphuric acids for lime and magnesia, the lime has the direct effect of retarding oxidation. This useful property serves to keep out low oxides of iron, bad enemies of all steels. The lime as a base unites with peroxide of iron and forms ferrate of lime in the slag.

Without entering deeply into the chemistry of the process, sufficient has been written to show that the method, as its name implies, provides bases for the absorption of the injurious gases set free by the heat. These gases having a greater affinity for the bases than for the metal, are chemically combined in the slag.

Within five hours from the charging the heat is ready to teem. This is practically a gain of fifty per centum in time and quality, as no steel is improved by being subjected, when fluid, to the fiercely oxidizing flame of fuel gas.

Qualities of basic steel.—Basic steel can be made purer than by any other known process; in fact, it can be made almost ideally pure. When very pure the tensile strength is low, but the reduction of area under stress is the highest. The strength can be raised by carbon alone to over 60,000 pounds per square inch, which is sufficient for ship-builders' needs. Low tensile strength is almost an emblem of purity in steel, and once having our steel at a known point of purity, we can raise its strength by carburization, with a certainty of not incorporating injurious metalloids. Basic steel has more the qualities of high-class wrought-iron, minus the blisters, slag, and laminations to which the iron is subject.

Basic steels weld very readily with ordinary care, and are much less susceptible to the evils of "blue heat" than other makes. Basic steel also possesses remarkable qualities as to malleability, and forges more easily than other steels. These qualities just enumerated fit it pre-eminently for fire-box and furnace-plates. Basic plates are free from snakes, one of the worst defects in thick plates or heavy sections. Basic steel is eminently fitted for angles, beams, and rivets. Its strength is not affected to the same extent as other steels by annealing, and instances are not wanting where it has actually gained tensility in the annealing furnace. No advantage is gained, as to quality, by subjecting basic open-hearth steel to excessive mechanical compression. The same uniformity of texture is gained by much less work. Basic ingots are much quieter in the moulds than acid ingots. Basic plates show less variations between longitudinal and transverse specimens than acid steels. In a record of thirteen heats from furnace No. 1, basic open-hearth, at the Homestead Steel Works, comprising one hundred plates and tests, the average variation between longitudinal and transverse specimens was: In tensile strength, 1120 pounds; in elastic limit, 870 pounds; in elongation, 8 inches, 2.2 per cent; whilst thirteen acid heats from furnace No. 4, of the same average strength and elongation, showed for the same number of tests average variations as follows: In tensile strength, 2740 pounds; in elastic limit, 1320 pounds; in elongation, 8 inches, 3.8 per cent. The analytical tests showed more uniform distribution and less segregation than in acid ingots. Examples could be multiplied, did not a paper of this description forbid the space necessary. The new basic material has found favor with the trade, and now that the Navy has admitted it as an equal, there can be only one feeling, and that of satisfaction.

Having thus followed the methods by which our steels are made with sufficient minuteness to judge of their probable defects and excellences, I now pass to the requirements exacted of the finished product before it is accepted.

STEEL FOR HULLS.

The desirable qualities may be enumerated in the following order of importance: reliability, toughness, strength, ductility, elastic limit, and durability, including vibratory endurance.

Reliability is dependent upon the uniformity and homogeneity of the steel. This is ascertained by physical and analytical tests. The physical tests are taken from the worst parts obtainable. The character of the fracture is highly important as an index of the flow of the metal. In this connection I will add that in judging the character of any fracture it is of importance to know how the fracture occurred. Steel as well as iron exhibits wide differences in the same metal, when pulled apart, from what it shows when broken by shearing strain.

Toughness is an element of the elongation, but is evidenced by bending, quenching, and, best of all, shocking tests by falling weights.

Strength or tensile strength is fully shown by the test specimens in the testing machine. These specimens are always selected from the worst portion of the plate, shape or casting, and should show the minimum strength. It should always be remembered that steel which has ever been subjected to strains approaching its ultimate strength, has passed from its original state of rest to one of stress, and its ultimate strength has been seriously reduced.

Ductility is also an element of the elongation, but is best shown by the reduction of area. The quality is valuable in permitting serious and emergency strains without rupture. In general, the milder the steel the greater the ductility, though there are startling exceptions.

Elastic limit is the true criterion by which loads should be adjusted. Simply stated, it is the strain which a given steel will endure without change of form. Unlike tensile strength, it actually increases under strains closely approximating, never exceeding, its full value. The elastic limit of any steel structure for all practical purposes is its true strength. This limit once exceeded, the structure is permanently weakened and deformed. It will be noticed that in the Specifications for Structural Steel no condition is imposed as to elastic limit. Given a mild steel with a certain tensile strength and elongation, conditioned as to phosphorus, and the elastic limit will follow. High phosphorus gives an abnormally high elastic limit.

Durability and vibratory endurance are shown by the fatigue of the metal during the drop test; the latter of the two being largely dependent upon pure metals rolled hot. Brittleness is fatal. In general, no steel for structural purposes should be admitted which requires nursing. Ordinary intelligent work must suffice for its incorporation. Rough usage and hard work are concomitants of ship-building, and the material must endure these without favor.

SPECIFICATIONS FOR HULL PLATES AND SHAPES.

The latest specifications, those of January 15, 1889, call for "steel of the open-hearth process, with not over .06 of one per centum of phosphorus."

"Plates and shapes to be tested by heats." [A "heat" may vary from five to fifty tons, but it is in all cases the output of a particular furnace for one run.]

"Tensile strength (practically) 60,000 pounds per sq. in."

"Elongation in 8 inches at least 25 per centum." [The distance between witness marks in determining elongation is important. The shorter the test piece the greater the per cent elongation. An elongation of 25 per cent in 8 inches corresponds closely to 32 per cent in 2 inches. Another point should here be noted. Elongation varies with the location of fracture. The nearer the grips the fracture occurs, the less the elongation, and the nearer the middle, the greater.]

"Cold bending pieces must bend over flat on themselves without sign of fracture." [Good steel, well rolled, will do this readily under a trip-hammer when not over $\frac{5}{8}$-inch in thickness. Thicker pieces should be placed in a hydraulic press, whose slowness and regularity permits a cold flow of metal. In this connection it should be remembered that wide pieces will not bend as readily as narrow ones.]

QUENCHING TESTS.

"Heat to a dark cherry red, then plunge into water at 82° F., and thus prepared it shall be doubled around a curve, whose diameter is not more than one and one-half times the thickness of the piece tested, without showing cracks." [Avoid smoky fires in heating the specimen or in heating any steels. This test should detect cold rolling, brittleness, or segregation of phosphorus.]

For shapes, *i. e.* angles, beams, bulb-bars, T and Z bars, additional tests are prescribed. Thus, "One bar in twenty to be opened out flat while cold, a piece cut from another bar in the same lot shall be closed down on itself until the two sides touch without showing cracks or flaws." [These tests disclose any injurious strains set in rolling. Of the two tests, that of closing is much the more severe. When the section is large and a trip-hammer used, the metal must possess excellent qualities of toughness, endurance and ductility to pass.]

The drop test prescribes, "two bars from every heat shall be tested to destruction by means of a falling weight." [When it is recalled that the bar is inverted at every blow, the severity of this punishment can be appreciated. No brittle or badly rolled bar can endure it, and all which do will withstand safely battery firing, collisions, or stranding.]

All material is subjected to careful surface inspection. The defects sought are slag, foreign substances, hard spots, laminations, sand or scale marks, scabs, pittings and snakes. A snake in steel has precisely the appearance of a water-mark in paper, and indicates the presence of burnt iron separating two layers of true steel. Any indication of a snake should arouse grave suspicion, and its proved existence should condemn entirely the plate or shape.

Shapes, in addition to the above defects, are inspected for defective sections, grooved fillets, wire edges, and shaded back; the latter being a rounding off of what should be a sharp, full shoulder.

HULL RIVETS.

These are now wholly steel made, are readily worked, and exhibit for equal sections 25 per centum more strength than the best iron. They are conditioned not to exceed .05 of one per centum of phosphorus, and restricted to open-hearth and Clapp-Griffith processes.

The T. S. must not fall below 55,000 pounds nor exceed 60,000 pounds, with an elongation of at least 29 per centum in 8 inches in the rivet bar.

The cold and hot hammering tests and hook bending tests are not severe for a mild, homogeneous metal. The shearing test exacts 40,000 pounds for ⅝-inch rivet.

THE WORKING OF STEEL.

The evil effects of working steel at too low a temperature, or at the "blue heat," as it is called, have been so widely discussed that it would be a work of supererogation to enlarge upon it. There are, however, two other errors that lead to evil consequences. First, overheating steel, or raising it beyond the necessary working or forging temperatures. In forgings there is a constant temptation to do this, as the forging can thus be kept longer under the hammer. Second, long soaking of steel in a fire. This latter causes the steel to become dry and brittle and does infinite harm. In general, soft steels from 45,000 pounds to 52,000 T. S. can be subjected to almost any kind of treatment without injury. Low steels possess all the good qualities of the best iron in this respect without its vices. Higher steels must be worked more carefully. The higher the carbon, the more skillful the workman should be.

ANNEALING.

Annealing generally reduces the tensile strength and increases elongation. It reduces strains by permitting intermolecular movements. The temperature should be raised slowly to allow the center to become equally heated with the surface. At no time should there be a wide variation in heat between the parts of the same piece. For the same reason the temperature should be as gradually lowered. Varying carbon steels require different annealing temperatures. Annealing properly performed serves a most useful purpose in removing strains set in heating, working, forging, rolling, and tempering. Carelessly annealed, a piece is not benefited and may be much injured. Punched plates, sheared edges, cold-bent shapes have had injurious strains introduced by cold flow, and though subsequent annealing may appear to have reduced their strength, the apparent loss is a real gain in uniformity. Thick plates should either be annealed or have their edges planed.

A "strain" in steel is a state of tension or compression between adjacent molecules, but always within the strength of the material. A "stress" is strictly a strain intensified until deformation ensues.

STEEL CASTINGS.

The Navy specifications call for open-hearth or crucible steel showing not over .06 of one per cent of phosphorus; the T. S. not less than 60,000 pounds per square inch, with an elongation of at least 15 per cent in moving parts and 10 per cent in stationary parts. Percussive tests are applied, and a large sledge used to discover cracks or brittleness. All castings are annealed.

It would seem that we are but at the threshold of the possibilities in steel castings. The difficulties to be overcome are excessive shrinkages, necessitating large sections and waste; surface roughness, causing the sacrifice of much metal in order to secure a uniformly smooth exterior; shrinkage cracks of greater or less depth and extent, always serious and frequently fatal; pitting, and sponginess. This last fault is one which bids fair to be eradicated entirely, but its existence is not an annoyance simply, it throws doubt upon the reliability of the whole casting. The evils we see we can estimate, but the possibility of blow-holes and sponginess in parts hidden from sight discredits the whole. High silicon is favorable to solid castings. The acid open-hearth process is now producing castings which bear comparison with wrought material, and we are nearing the time when steel castings will displace many forms of forged material. Steels melted by radiation are freer from blow-holes than other steels.

Aluminium alloys increase the tensile strength and to some extent the elastic limit, but both these gains are made at the expense of ductility. In high carbon castings, aluminium is positively disadvantageous. Sharper castings are obtained by aluminium alloys, and there may be fewer shrinkage cracks, due to greater fluidity at a lower temperature in pouring. Beyond these advantages claimed, there is much doubt as to the merit of further alloying an already impure metal.

BOILERS, STAYS AND RIVETS.

The comparatively recent adoption of exclusively steel boilers for the Navy marks an era of greatly increased pressures. A general knowledge of the character of the material of which they are constructed is useful to all classes of officers. The writer gives here the class of steel used and a few observations as to its merits. In so doing he is painfully aware that to many of the members he is simply "carrying coals to Newcastle."

All boiler plates must be made of open-hearth steel, conditioned not to exceed .035 of one per cent of phosphorus. This practically gives us phosphorus at .030 of one per cent. Speaking from observation, I should like to see the phosphorus reduced to a trace.

Each boiler plate is tested independently and stands or falls upon its own merits. Test specimens are cut *either* longitudinally or transversely. This is important, as physical qualities vary widely in transverse specimens as compared with longitudinal specimens from the same plate; the transverse specimen showing higher tensile and lower elongation. The transverse specimens for shell plates must have T. S. between 58,000 pounds and 67,000 pounds, and an elongation of 22 per cent in 8 inches. The longitudinal has the same range in tensility, but an elongation of at least 25 per cent. The elastic limit is fixed at 32,000 pounds.

Furnace and flange plate are required to show T. S. from 50,000 pounds to 58,000 pounds, with 26 per cent elongation *either* longitudinally or transversely. Cold bending and quenching tests are the same as for ship plate. Plates over ¾″ thick must not be sheared, but planed to finished dimensions.

Boiler rivets are conditioned to .03 of one per cent in phosphorus, and the other requirements are: T. S. 50,000 to 58,000 pounds, elongation 30 per cent in fire-box rivets; T. S. 58,000 to 67,000 pounds, elongation 26 per cent in shell rivets. For rods, shapes, and forgings for boiler bracing when in contact with the fire: T. S. 50,000 to 58,000 pounds, elongation 26 per cent. All other bracing: T. S. not less than 65,000 pounds, elongation 24 per cent. The usual cold bending and quenching tests follow.

The great economy of fuel in high-pressure boilers has been a powerful incentive to stronger shells and furnaces. Our new cruisers, with boilers 15′ 9″ in diameter, working under pressures of

160 pounds per sq. in., show how far in this direction our engineers have progressed. The factor of safety has suffered a reduction, but the excess of strength is still very large. Boilers designed for eighty pounds pressure were supposed to have a factor of safety of nearly five. To require a similar factor from a boiler designed for one hundred and eighty pounds is excessive. Testing such boilers to over twice the working pressures might result in distressing the boiler or fatiguing the metal. No matter what the ultimate strength may be, no boiler should ever be subjected to a pressure beyond its elastic limit. There is a possible danger in using extremely wide plates for boiler construction. Sheets over seventy inches in width are more apt to develop defects than narrower plates. We shall be told, in reply, that wide plates are preferable to so many riveted seams. We know that these riveted joints are not as strong as the plate itself should be, but we do know that their strength is nearly seventy per cent of the plates, and no man dares to say, not how much, but how *little* strength there may be in a wide plate cold rolled.

A working pressure of 160 pounds gives six tons pressure to the square inch on the plates, and about eight and one-half tons between rivet holes. As the elastic limit is but sixteen tons, it would seem that we had gone quite as near that limit as prudence permits. It will be seen what an enormous advantage has been gained in pressures by the adoption of such an extremely fine material, mild steel, and the thorough testing of each individual plate.

Our new boilers will be fed with fresh water supplied by separate distillers, and the old problem of "loss by blowing" will fall into oblivion and cease to harass the soul of the naval cadet.

The necessity for great margins of strength in marine boilers is owing to: 1. Possible latent defects in material; 2. errors or defects in workmanship; 3. exceptionally severe strains (from causes unforeseen) other than those for which the boilers were designed; 4. constant weakening caused by corrosion.

Note.—Very few boilers ever wear out or corrode in the shell. The flange or furnace plate first give way, they suffering most from corrosion and from unequal expansions.

ENGINES AND SHAFTING.

Forgings are conditioned below .06 of one per cent in phosphorus, and only open-hearth steel is used. All forgings must be annealed and after annealing show T. S. from 58,000 to 67,000 pounds, with an elongation of at least 25 per cent. Quenching and cold-bending tests are also required. The low tensility with the good elongation should ensure a metal possessing great vibratory endurance. Each section of shafting is tested separately. For crank and wrist pins tensile strength of 80,000 pounds is required and an elongation of 12 per cent. With the recent tremendous increase in size and power of rolling and cogging mills there seems no reason why rolled shafts should not be made. At least one mill in the United States is capable of rolling sections of 22″x22″ from ingots weighing fifty tons each at one heating. The many objections against hammer-forged material, especially when the object is too long for simultaneous heating, are well known. I am aware of no advantage gained by hammering over rolling, and there are grave drawbacks in the condition of large sections hammer-forged. A shaft that, by rolling at one heat, has suffered the same mechanical reduction and compression, must have its molecules in a more perfect state of rest than a shaft which has been broken down step by step through successive hammerings and local heatings.

In annealing forgings or castings nothing is gained by exceeding a temperature above bright cherry red. This color temperature permits free intermolecular movements, and a higher degree of heat may very possibly render the steel harder on cooling.

ANCHORS.

The anchors now making have cast-steel crowns and flukes, with forged wrought-iron shank. The type adopted has no stock. The requirements for the cast steel are, after annealing, T. S. 60,000 pounds; elongation in 8 inches, 15 per cent; conditioned in phosphorus, .06 of one per cent. These anchors weigh 6500 pounds and 7500 pounds. The increase in strength over the best iron anchors exceeds 35 per cent. No attempt has been made to reduce the sections, as loss of weight would be a positive decrease of efficiency.

CHAINS.

The navy iron chains now made at the Boston Navy Yard have always borne a high reputation for reliability, though instances are known of their parting in the welds. I am not aware of any steps taken to introduce steel in place of iron. I can see no reason why such substitution should not be made. The steel bars from which such chains should be made are as reliable as iron bars or rods. With the introduction of electric welding the only serious objection to their adoption has passed away. The great gain in elastic limit, elongation, and ultimate strength cannot be denied. Composed of mild steel, no more trustworthy material could be found. As to cast-steel chains, they have been made with apparent success in England and France. We have none of domestic manufacture.

STEEL RIGGING AND ROPES.

For standing rigging, galvanized steel wire is used. The requirements are: T. S. 160,000 pounds; elongation in 10 inches, 1.5 of one per cent; elastic limit, 80,000 pounds. In addition, vibratory tests are prescribed as follows: angle of vibrations, 40°; number of vibrations, 1300.

For running rigging, such as topping lifts, wheel ropes, lifts, etc., galvanized annealed steel wire is preferred. The requirements are: T. S. 75,000 pounds; elongation in 10 inches, ten per cent; elastic limit, 38,000 pounds; angle of vibrations, 40°; number of vibrations, 500. These tests tell their own story as to the material.

STEEL FOR GUNS.

The Bureau of Ordnance requires for the new, high-powered, breech-loading rifles, steel of open-hearth process. With the exceptions of the trunnion bands and elevating bands, all parts of the gun proper are forged steel. The trunnion band is of cast steel and the elevating band of wrought iron. The manufacturer of the steel is required to discard thirty per cent of the top of the ingot and five per cent of the bottom. This gives a more solid, uniform and homogeneous section than if the whole ingot was taken, as the greatest segregation is in the top center of an ingot.

Tubes, jackets, and hoops are required to be made from solid ingots, which are afterwards bored. For tubes the bored ingot must be reduced fifty per cent in thickness; plugs and mushrooms the same. The jacket is reduced forty per cent and the hoops at least thirty-three per cent. All forgings and the trunnion band must, after forging is completed, be annealed, oil-tempered, and again annealed. The virtual requirements as to physical qualities are:

	T. S. Pounds.	Elastic limit. Pounds.	Elongation, 2 in. Per cent.
Tubes,	70,000 to 80,000	33,000 to 38,000	12 to 22
Jackets,	74,000 to 85,000	34,000 to 40,000	12 to 20
Hoops,	90,000 to 100,000	45,000 to 50,000	12 to 18
Trunnion bands,	80,000 to 90,000	36,000 to 40,000	6 to 12

The tubes, jackets, and hoops are forged closely to dimensions, but the trunnion band is cast with fifty per cent waste metal in the mould.

The hoops and jackets are bored first, and the exterior of tube and jacket afterwards turned to the same dimensions plus the shrinkage. The jacket and hoops have each shrinkages assigned, varying with variations of the physical qualities of the steel of which they are composed. These shrinkages run from .009 of an inch to .026 of an inch. All shrinkage surfaces are turned and bored to .001 of an inch. To assemble the parts it is necessary to expand the jackets and hoops by heat. The requisite expansion is obtained by heating them over a wood fire. The tube is kept cool by water circulation. The jacket being assembled, hot, is kept from shrinking back longitudinally by running cold water on the forward end, thus locking it there. The gun is hooped to the muzzle; the chase hoops, three in number, being long and tapered. The trunnion band screws in place and is locked with a set pin. The compression obtained on the bore of the tube by the jacket and chase hoops is about .006 of an inch. The breech hoops shrunk over the jacket increase this to a total compression of about .010 of an inch. The tempering has already established in tubes, jackets, and hoops a state of compression, and by the shrinkage obtained we have largely increased the elastic limit. More than in any other steel structure, this elastic limit in a gun is the true criterion of its strength. Exceed it, and the gun is deformed, and the slightest deformation in a gun is fatal. The longitudinal clearances of the hoops and jacket, after assembling, are very small. The total clearances of the jacket, D, E, F, and G (which constitute all the hoops in contact with the tube), frequently amounts to less than .010 of an inch. The breech mechanism is all steel of the DeBange system. The guns have proved their excellence, and their endurance is great. The Navy is fully committed to built-up guns, and it is to be congratulated on the prospect of soon possessing such efficient weapons. The 6-inch and 8-inch calibers are now afloat. Of the 10-inch we have as yet none of domestic manufacture. With the completion of the Bethlehem, Pa., hydraulic forging works the present year, we shall be prepared to turn out calibers of 10-inch, 12-inch, and 16-inch.

STEEL CAST GUNS.

Under act of Congress, two 6-inch steel cast guns, weighing about 5½ tons each, have been offered for statutory trial. The first to be tried was of Bessemer steel, cast by the Pittsburgh Steel Casting

Company. About twenty thousand pounds of metal were poured, the gun being cast solid. After rough-boring, the gun was first annealed, then tempered by a peculiar and unique process, and again annealed. After rifling at the Washington Yard, the gun was taken to Annapolis for prescribed trial. This condition imposed ten rounds in quick succession. The charge was to be sufficient to give a muzzle velocity of 2000 foot-seconds to a 100-pound projectile. A preliminary blank charge being fired, the gun was loaded with forty-eight pounds of brown prismatic powder and projectile. The gun went to pieces abaft the trunnions, the bursted segments completely wrecking the heavy 12-inch timbers built over and around it. The pressure gauge indicated fourteen tons. As the usual energy of such a charge is fifteen tons, it is evident that the walls of the gun gave way before the gases had been fully evolved.

The physical characteristics of the metal were:

	T. S. Pounds.	El. L. Pounds.	Elongation. Per cent in 2 inches.
Breech, long.	89,686	51,693	9.75
" trans.	73,236	57,290	0.60
Muzzle, long.	81,185	40,461	18.00
" trans.	79,174	41,500	16.50

The wide variations and almost total absence of elongation in the transverse breech specimen are full of significance. It will be noted that the breech specimens are very unsatisfactory, and when it is known that the gun was cast breech up, of indifferent metal, with an utterly insufficient sinking head, the reasons for the poor quality are evident. A careful chemical analysis of the borings and turnings of this gun, taken every two inches along the length, constituted probably as good an instance of lack of homogeneity and segregation as can be found in any record. That such a gun should enter the lists and go upon any record as an exponent of any steel cast system is worse than a travesty. Its utter failure has proved that poor steel, poorly treated, cast without any of the usual safeguards, and afterwards annealed, tempered, and annealed again by a process which was as strange to the manager as it was to the metal, will not bear strains which call upon the best steels for all their strength and elasticity.

With regard to the second steel cast gun the case is different and the results important. Cast by the Standard Steel Casting Company of Thurlow, presumably of the best material, and with every precaution their large experience could suggest, it can be considered as a fair exponent of the cast-steel system. The gun endured the ten statutory rounds without rupture, but the serious enlargement of the bore, as evidenced by subsequent gauging, is conclusive. The elastic limit of the metal has been exceeded, and the gun, for ordnance purposes, irreparably injured. The trials of these two guns prove that, for the present at least, we must rely upon the system of built-up guns now adopted.

The trials in Sweden of the 3.2-in. and 4.3-in. steel cast rifles, with pressures from ten to thirty-five tons per sq. in., show that the system can be made successful for small calibers at least. It is useless to go over the well-worn arguments of built-up versus steel cast guns. Certainly the built-up advocates have the best of the argument and the facts. Still, I hazard little in saying that the question may assume a different aspect with the improvement in castings. At best, hammer-forging is brutally severe on steel, and the dozen parts which go to constitute the present high-powered rifle may be reduced in number without loss of strength.

The present system has as a strong support in its favor, the practical impossibility of incorporating bad steel in any gun, and with the completion of the new shop at the Washington Yard, the Ordnance will be able to supply all the probable wants of the Navy.

GUN CARRIAGES.

As to the carriages now in use there is nothing to be said, they not being of steel. A new carriage—the pneumatic gun carriage—is now being tested at Annapolis, whose parts are all of steel, and which, in a degree, is dependent upon the strength and ductility of that metal in the sudden and violent strains to which a carriage is subjected. A few rounds have been successfully tried with an 8-inch rifle, and without forestalling the action of the board, we can safely say it promises well.

As designed for 8-inch B. L. R.'s, the weight is 16,000 pounds. [Bureau's hydraulic carriage, 8 inch, weight is 20,000 pounds.] Every part is of steel. The slides are horizontal, and the downward strain is taken entirely from the deck, excepting the component due to impact. The strain from the recoil is taken up *in line* with the horizontal side-cheeks and pulls directly on pintle. In the 8-inch carriage the initial air-pressure in the recoil cylinders is 250 pounds per square inch. The mean pressure during recoil is 729 pounds, and the maximum pressure at end of recoil is about 1900 pounds. The length of recoil is two feet. Any shorter recoil desired can be secured by increasing the initial pressures in the cylinders. The carriage is trained and the gun elevated and depressed by one man standing at the rear. The extreme elevation is 18° and the greatest depression 5°. Hand power can be used for this purpose when desired. The air for the cylinders is furnished by an engine and compressor below decks, but the recoil cylinders once charged need no further attention, a hand-pump serving to recharge in case of leakage.

The air, at a pressure of 80 pounds, for working the training and elevating engines, must be kept supplied by the compressor below. [The experience on board the Atlanta as to working 8-inch guns by hand should be conclusive as to the need of power.]

The recoil cylinders have no valves, the difference in diameter between the piston and the cylinders allowing the air to pass from rear to front of piston in recoiling. By this means excessive pressures are avoided, though the cylinders are designed for 4000 pounds per square inch. The counter recoil is checked by the air passing from front to rear. The difference in area between piston face and back (the area of back being diminished by the area of piston rod) is sufficient to bring the gun always back into battery. The serious dangers of using compressed air under pressures varying from four hundred to two thousand pounds per square inch on open battery decks, the probabilities of leakage, and the possibilities of an enemy's shell, are disadvantages of all pneumatic systems.

In this somewhat rapid survey of Navy steels, no mention has been made of machine guns, small arms, torpedo outfits, or a hundred minor uses. Stress has been laid more upon general methods and treatment than special applications. The growing severity of the specifications will be noted, and the Navy is to be congratulated that these are constantly above and beyond commercial demands.

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

REMARKS (ON BOARD THE U. S. F. PRESIDENT, COMMODORE RODGERS), MADE BY M. C. PERRY.

The following extracts are taken from the original Remark Book of M. C. Perry, kept by him while attached to the U. S. frigate President, under the command of Commodore Rodgers during the years 1811–12 and 1813. Only those parts that are of special interest are given, such as the action with the Little Belt, the pursuit of the Belvidera, and the chase of the President by a line-of-battle ship and a frigate. While these remarks are very concise, they evidently contain the impressions of the writer at the time the affairs mentioned took place, and are therefore valuable as historical evidence. In the case of the Little Belt they show that while Commodore Rodgers was cruising in Chesapeake Bay he heard of an American vessel being boarded by a British sloop-of-war, and he was evidently searching for the Little Belt when he fell in with her. According to the remarks, the Little Belt fired first, but it is evident that Commodore Rodgers was anxious and willing to punish her for attempting to exercise the so-called "right of search." The account of the chase of the President by a line-of-battle ship and a frigate is peculiarly interesting, as it supports the letter of Commodore Rodgers on the subject, and entirely controverts James' account of the same affair. Roosevelt, in "The Naval War of 1812," seems to feel obliged to adopt the account of James because the latter professes to quote from the logs of two British vessels, the 32-gun frigate Alexandria and the 16-gun sloop Spitfire. James declares a mistake to have been impossible, and that Commodore Rodgers knew the force that was pursuing him—in fact, was a coward. Roosevelt admits the truth of the supposed logs and arrives at the conclusion that Rodgers was mistaken in the force, and that he was over-cautious in not standing sufficiently near to ascertain the strength of the enemy. This verdict of over-caution is the more severe because of the able and judicial character of Roosevelt's deductions. It does seem almost impossible to believe that James could have deliberately invented these logs, and yet Roosevelt has clearly shown how he always misrepresents the facts and falsifies history so as to vilify the Americans. James shows a vicious animosity against all of the American naval officers, and especially so against Commodore Rodgers because of the punishment he administered to the Little Belt. M. C. Perry, then a lieutenant, confirms the account given by Commodore Rodgers ; his high reputation is too well known to imagine that he would falsify willfully his personal remark book. It seems impossible that either he or Commodore Rodgers could have mistaken a 32-gun frigate for a line-of-battle ship at the distance of seven miles in clear weather, or a 16-gun sloop for a frigate when within five miles. All Commodore Rodgers' history shows that he was not over-cautious. He assumed great responsibility in seeking out the Little Belt; he pursued the Belvidera, a 36-gun frigate, and would have captured her but for the bursting of one of the guns, by which he was wounded. This account must brush away the cloud which has been allowed to rest on one of our great naval names, and James' account must be accepted as still further evidence of his moral obliquity. The remarks commence Tuesday, March 19, 1811, and end July 25, 1813. Matthew Calbraith Perry became a midshipman on January 16, 1809, and a lieutenant on July 24, 1813. His connection with the opening of Japan is well known to his countrymen.

R. W.

ACTION WITH THE LITTLE BELT.

May 15, 1811.—Commences with light breezes and clear. At 2 came to in 5½ fathoms, Cape Henry light bearing west, distant about seven miles. Sent the pilot (Mr. Jones) on board the ship Madison, bound for Baltimore. At half-past five got under way and stood to sea, Cape Henry lighthouse bearing W½S, distant nine miles. At 10 spoke the brig Sally and supplied her with provisions and water.

May 16.—Commences with moderate breezes and pleasant weather. At 3.30 spoke a schooner from Philadelphia bound to Wilmington. Soundings from 17 to 19 fathoms. Ends moderate and pleasant. Nine sail in sight.

May 17.—Commences with light breezes from the northward and eastward, with clear, pleasant weather. At half-past twelve tacked to the southward and eastward. At 1 P. M. discovered a strange sail standing for us under a large press of sail and bearing ESE. In about five minutes she displayed her signal. We hoisted our ensign and pennant and cleared ship for action. At 2 the above-mentioned vessel, not finding her signal answered, wore and stood to the southward and westward, and set her larboard lower studding-sail. At 2 beat to quarters. At 4 P. M. moderate and clear, the chase bearing SE, distant about ten or twelve miles, making sail gradually. At 6 the chase appeared to haul about a point to the southward; at 7 P. M. she took in her studding-sails, distant about eight miles, and at ten or twelve minutes past seven she rounded to on the starboard tack. At half-past seven we shortened sail, and at half past-eight rounded to on her weather beam, within a cable's length of her. Hailed and asked "What ship is that?" to which she replied, "What ship is that?" and on the commodore's repeating his question, we received a shot from her, which was immediately returned from our gun-deck. This was hardly done before she fired three other guns, accompanied with a volley of musketry. We then commenced a general fire, which lasted about fifteen minutes, when the order was given to cease firing, our adversary being silent and apparently in much distress. At 9 hauled on a wind on the starboard tack, the strange ship having dropped astern so far that the commodore did not choose* to follow, supposing he had sufficiently chastised her for her insolence in firing into an American frigate.

We kept our battle lanthorns burning, and after having examined the damages, found that the ship had her foremast and mainmast wounded and some rigging shot away, and one boy wounded. Before daylight the masts were fished, woolded and painted, and everything a-taunto. At 5 A. M. discovered the strange sail, bearing SSW, distant about seven miles. Set the foresail and bore down for her; at 8 came alongside and sent a boat aboard of her. She was lying in a very shattered situation—no sails bent, except her maintopsail; her rigging all shot away, three or four shot through her masts, several between wind and water, her gaff shot away, etc. At 9 the boat returned. The stranger proved to be the British ship-of-war Little Belt, Captain Bingham. We permitted her to proceed on her cruise, hoisted the boat, and hauled by the wind on the larboard tack.

* A supposition.—M. C. P.

(The interval till June 21, 1812, was passed in cruising along the eastern coast, between the Chesapeake and Newport, R. I., with occasional short stays in port.)

PURSUIT OF THE BELVIDERA.

New York, June 20, 1812.—At 10 A. M. news arrived that war would be declared the following day against Great Britain; made signal for all officers and boats, unmoored ship, and fired a salute.

Horse Shoe, Sandy Hook, June 22.—At half-past three P. M. crossed the bar in company with the frigates United States and Congress and the sloops Hornet and Argus, the Hornet just from the city with news of the declaration of war against Great Britain. At 6 spoke a pilot-boat, who informed us there was an English armed vessel to the northeast. Made all sail in chase, and at 8 fired a shot ahead and brought to the stranger, who proved to be the American ship Powhatan, bound to France with General Moreau passenger.

June 23.—Nothing remarkable these twenty-four hours, except speaking a brig, who informed us that four days before she had spoken a fleet of English merchantmen, consisting of thirty sail, from the West Indies bound to England, and convoyed by a frigate and a sloop. At 8 A. M. discovered a strange frigate to windward, standing from us. Hauled our wind and made all sail in chase.

June 24.—Moderate breezes and clear. At half-past twelve the chase hoisted English colors, and the wind hauling, she set her steering sails and stay-sail. At quarter-past four, having come within gun-shot of the chase, and observing that she was training her stern-chasers on us, we commenced firing with our bow guns. She immediately returned our fire with her stern-chasers. We then yawed and gave her the larboard and starboard broadsides, and continued the fire from our bow guns, the Congress (the nearest ship) being about three miles astern. At three-quarters past four the starboard bow gun on the gun-deck burst, and killed and wounded a number of men, John Rodgers, Esq., commander, Thos. Gamble, lieutenant, M. C. Perry, midshipman, and eleven men being wounded, and Midshipman John Taylor killed.

At 5 the chase commenced a fire from her gun-deck, but without effect. Gave her two or three broadsides, when, finding herself in a desperate situation, she threw overboard everything at hand to lighten her. Among the articles thrown over we observed pass us four boats very much shattered, a number of planks, spars, and barrels, and this enabled her to drop us so fast that in a short time she was out of gunshot. We, however, continued the chase until 11 P. M., when we shortened sail, having been exposed to the raking fire of the enemy's four stern-chasers for about two hours and thirty minutes. Our killed were John H. Bird, midshipman, and one marine; our wounded, L. Montgomery, midshipman, and four men, one of whom since died.

Latter part clear and pleasant. All hands employed repairing damages. Committed the bodies of Midshipmen John H. Bird and John Taylor to the deep.

CHALLENGE OF THE SHANNON AND TENEDOS.

May 1.—At 2 Boston lighthouse bore by compass WSW, distant 4 leagues. At 5 P. M. Thatcher's Island lights bore by compass W by N, distant about 3 leagues. Discharged pilot.

NOTE.—On our leaving Boston we saw everything cleared for action, expecting to fall in with the British frigates Shannon and Tenedos, vessels that a few days previous to this had appeared off our harbor, well knowing we were not ready for sea. We, however, supposed that it would not be consistent with the British pride for them to withdraw themselves after having sent so many messages to Commodore Rodgers. We had the mortification, however, to find on our gaining the offing, that even their pride and self-conceit could not compel them to keep their cruising ground.

	Guns.	Men.
Frigate President, ...	55	450
" Congress, ...	50	420
" Shannon, ...	54	500
" Tenedos, ...	54	500

THE PRESIDENT CHASED.

July 18.—At 6.30 P. M. the North Cape bore by compass SE by E, distant about 7 leagues. At 11.45 P. M. (North Cape bearing east) discovered a strange sail. Made sail in chase. At 3 captured the English brig Daphne, from South Shields to Archangel, in ballast. Took everything of value out of her, and sank her by firing three of our quarter-deck guns loaded with round shot and grape. Discovered a strange sail in under the land. Made all sail in chase.

July 19.—The chase fired two guns and hoisted signals. At 1.35 she hove to, proving to be the American privateer schooner Scourge, Nichols, commander, from New York, on a cruise. At 3 A. M. (Scourge in company) discovered a strange sail bearing N by W. Made sail in chase. At 5 spoke a Russian ship from Archangel bound to Norway.

July 20.—At 4 P. M. discovered two strange sail bearing WSW. Made sail in chase. Light winds. At 7 P. M. found the strangers to be a line-of-battle ship and a frigate, standing on a wind to the northward and eastward. Took in studding-sails and hauled by the wind. At 8.30 tacked to the northward and westward, the strangers tacking at the same time (Scourge in company). Latter part pleasant. Strange sail still in chase of us. Lat. 71° 49′ N. At meridian the strange sail bore by compass SE½E, distant about four leagues. Found that they were gaining, owing to their having a much larger number of light sails. The Scourge hauled off to the westward and we lost sight of her.

July 21.—Strange sail coming up fast. Wet our sails, cleared ship for action, and got the stern-chasers out. Under all sail. Strangers still coming up. At 12.15 gained considerable ground on them by a very handsome manœuvre, having a fine breeze, with studding-sails set on both sides, the enemy on our larboard quarter. Edged a little to starboard, and they, perceiving this, hauled to starboard a little. In a moment we took in starboard studding-sails, jibed ship, and luffed athwart the enemy's bows.* Breeze leaving the enemy fast, the foot of their topsails just discernible from the deck. At six lost sight of the strangers. At 10.30 discovered them again.

July 22.—At 4 tacked to the northward, the enemy bearing NE½E. At 4.45 tacked to the southward and westward; enemy gaining on us. From 4 till 8, light breeze and thick, hazy weather; enemy coming up fast, having the advantage of a fine breeze. Saw everything clear for action. At 11 A. M. getting the breeze that had favored the enemy. Dropped them fast. At meridian the enemy's frigate bore E by N, distant about five miles. The line-of-battle ship N by E, distant about seven miles.

July 23.—Enemy still in chase of us. At 8.45 hoisted American colors and fired a gun to windward. Took in royals for the frigate to come up; but she avoided us by standing for her consort, who was considerably astern. At 10 lost sight of the two strange sail.

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* Had a double motive for hauling to the westward. We were fearful of running into the ice.

July 25.—Captured the British whale-ship Eliza Swan, from the coast of Greenland, bound to Montrose, Scotland, 8 guns and 48 men. Put all our prisoners on board of her (numbering thirty-two) on parole. Ransomed the ship.

The following extract from the journal of Lieutenant Raymond Perry gives additional and conclusive proof of the truth of Commodore Rodgers' account of the President being chased by a line-of-battle ship and a frigate:

JOURNAL OF A CRUISE ON BOARD THE U. S. FRIGATE PRESIDENT, 44 GUNS, COMMODORE RODGERS.

Tuesday, *July* 20, 1813.—Moderate breezes and cloudy. At 4 P. M. discovered two strange sail bearing WSW, apparently within a mile of each other. Made sail in chase. At 7 P. M. made the two strange sails out to be a line-of-battle ship and frigate standing on a wind to northward and eastward. Took in our studding-sails and hauled on a wind. Made signals which were not answered. At 7.45 tacked to the northward and eastward. The Scourge tacked at the same time. At 8.30 tacked to the northward and westward. The two strange sails tacked also. At 12 light winds and variable. The strangers in pursuit under a press of sail, at meridian light winds, distant 4 leagues. Latitude, ob. 71° 49′; longitude—

Wednesday, *July* 21.—Light breezes from the eastward, and clear. The two strange men-of-war in chase of us, hull down. At half-past two P. M. the foot of their topsails just discernible; at six lost sight of them. At — discovered Cherry Island, bearing N by E, distance 8 or 9 leagues; tacked ship; discovered the two ships of war bearing S by E. At meridian, moderate breezes and cloudy. The two ships of war in sight, bearing SE. Latitude by obs. 73° 47′; longitude—

Thursday, *July* 22.—Moderate breezes and cloudy. At 4 tacked to the north; 2 ships of war in sight. At 11 could see but one of the men-of-war from the deck. From 4 till 8 A. M. light breezes, thick and hazy. At 10 the strange ships coming up with us, the smallest ship the headmost vessel, and both their hulls in sight from the deck. All hands employed clearing ship for action, getting stern-chasers in readiness, etc. At half-past ten, catching light breeze, appeared to hold our own. At meridian, light breezes from the N and W. The men-of-war in pursuit, distance about 2¼ leagues. Latitude by D. R.—; longitude—

Friday, July 23.—At meridian, light breezes and clear. The two ships of war in chase of us, their hulls in sight from the deck. At 8, fresh breezes, dropping the two ships of war. At 45 minutes past 8 hoisted our colors and fired a gun to windward. At quarter before 10 the nearest ship furled her royals and luffed up, apparently to join her consort. Furled our royals at 10 A. M.; lost sight of them. Mer. under press of sail.

Saturday, July 24.—Begins with moderate breezes and cloudy. Under a press of sail. Lost sight of the two ships of war. At 45 minutes past 11 discovered a sail bearing SW by W½W; at meridian, moderate breezes. Latitude by D. R.—; longitude—

Sunday, July 25.—Fresh breezes and cloudy; all sails set in chase. At half-past 1 the chase hove to. At 45 minutes past 1 the chase filled away under a press of sail; made sail after her. At half-past 2 brought to board and captured the English ship Eliza Swan, from a whaling voyage bound to Montrose, mounting 8 guns and manned with 48 men; John Young, master. Ransomed her for 5000 pounds sterling. Sent on board of the prize 3 masters, 3 mates and 22 seamen, the crews of former captures on their parole; filled away and made all sail. The prize filled away and steered SW. At meridian, fresh breezes and thick, hazy weather. Latitude, by obs. 65° 35′. Longitude—

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

CRUISE OF THE U. S. SLOOP-OF-WAR VANDALIA IN THE PACIFIC IN 1858, UNDER THE COMMAND OF COMMANDER ARTHUR SINCLAIR, U. S. N.

The following extracts from the private letters of Commander Sinclair were furnished by his son:

Nuka Hiva, August 5, 1858.—Just as I was about getting under way for Tahiti, a boat was reported to me entering the harbor with an American flag flying, and in her four men. She came alongside, and in her were the captain, chief mate, and two men of the American clipper-ship Wild Wave, of Boston, bound from San Francisco to Valparaiso, wrecked on the 4th of March last, on the island of Oeno, lat. 24° S., long. 130° 41′ W.

The captain informed me that he had left on the island, a little spot scarcely larger than this ship, 38 of his crew. The ship had not, when he left, gone to pieces, and they were employed in endeavoring to save as many provisions from her as possible to subsist on. He left five months ago in search of assistance, and was again cast away on Pitcairn's Island, just to the southward, and there remained four months.

Pitcairn's Island was once inhabited by the mutineers of the Bounty, but all have removed to Norfolk Island, leaving behind them a plenty of fruit and vegetables, upon which the captain and his party subsisted until they built the little boat in which they came over to Nuka Hiva, a distance of one thousand or more miles.

The captain is a married man with one child, and miserable, of course, about his poor wife, as of course she has had no tidings of him for six months, and will take it for granted he has perished long since. He also tells me that he had the remains of his brother on board, who died at San Francisco, and he was taking him home for burial, for the sake of his aged parents, who reside in Massachusetts.

Poor man! he is entirely destitute, but nothing seems to trouble him so much as his wife and her anxiety about him, and his eyes brim up upon all occasions at the mention of her. I have made him very comfortable in my cabin, and got immediately under way for Tahiti, where he may have a chance of getting home by the way of San Francisco, or at any rate of writing. The mate and two men I shall take with me down to the island in search of their companions; shall stop only a few hours at Tahiti to fill my water and wood. Should I find them, shall have a large addition on board, and shall require all the water I can carry and provisions also.

I also found and have on board three distressed American seamen from Nuka Hiva, who were left there by an American whale-ship, so you see I am doing good in a small way, and am compensated in a measure for the loss of my letters.

Going to this island will not defer my arrival at San Francisco much, as I shall necessarily have to give up some of the places named in my orders. The captain found on Pitcairn's Island a sermon left by the people when they departed, from this text, "The Spirit and the bride say, Come." They found the island too small for their increase of population and abandoned it. He was very near landing on his way on an island near Nuka Hiva, but fortunately did not, as they are all cannibals and would certainly have eaten them. They had a human sacrifice there but a few days ago of their own women and children. The captain says it is impossible to imagine his feelings upon the discovery of the American flag waving on board the Vandalia as he entered the harbor—only one vessel in port, and that a ship of war of his own country, and fully able to protect and assist him.

I think we can all enter fully into his joy. Thank God that he has been pleased to place me here and make me the source of his delight and that of his now wretched family. He saved from the wreck $13,000, which I have on board in gold, and although he was only a few hours at Nuka Hiva, sold his boat, which I could not stow, for $240 to one of the missionaries of the island.

At sea, August 7.—I think the captain will leave at Tahiti. He seems anxious about his family. His name is J. N. Knowles, chief mate J. F. Bartlett, seamen William Teele and Wm. F. Clayton. You had better drop the captain's wife a line. Her residence is Brewster, Mass. Captain Knowles tells me he found plenty of everything on Pitcairn's Island, and a lovely spot it is. He cut the timber of which his boat was constructed from the woods, and burnt several of the houses on the island to get from them the nails which he used. The tools he found there. God has certainly been with him through all his troubles.

Tahiti, *August* 11.—Arrived yesterday and sail to-day to the relief of those poor men. None of them have arrived. Another vessel was wrecked, not an American, and all hands eaten up by the natives. A poor woman on shore here had two children on her. I shall send this by a French ship-of-war to Honolulu. The captain does not go down with me, but his mate and men will. I am driving up things with a rush. Shall return here, and you will hear from me again, I hope, before I go to the other islands.

At sea, *August* 13.—God is certainly with us, as right in the region of head-winds I am going on my course nine knots. I fear our great trouble will be to get them off the island, as it is entirely surrounded by a reef with a frightful surf on it, a mile and a half from shore, and no opening through, even for a boat; but the danger must be encountered if they are alive and there. I have many plans in my head, and one is to send casks in with stout lines from boats outside, with life-preservers on them, and haul them through the breakers. The mate says the breakers are tremendous and a boat would stand no chance; but God will, as he has ever done, protect us. This island has wrecked a number of vessels. The captain saw some pass there while on the island. Captain Beechy of the English navy landed on it and lost one of his men.

August 22.—As I said on the previous page, God has been with us. I reached here to-day after an awful spell of weather and found the whole party—with the exception of the boatswain, who died on the 7th—still on the island and well, and have gotten them, bag and baggage, safely on board, together with the remains of the poor captain's brother, and not an accident has occurred; but, oh! such an undertaking, it would have made your hair stand on end to have seen our boats passing and repassing through the surf—all manned with volunteers stripped and with life-preservers on, and the ship lying just outside the breakers to receive them as they were brought off. I could not draw a long breath during the whole process, but thank God all is over and I have now on board thirty-seven fellow-beings saved from death by starvation, and am now on my way to Pitcairn's Island to take on board the three left there by the captain, who were afraid to embark with him in his little boat. The feeling of these poor creatures on seeing our ship can be better imagined than described. They were running about in all directions and making all sorts of signals to attract our attention, not knowing that we were after them, and as I rounded to, close to the breakers, I fired two guns and ran up the star-spangled banner, the flag of their country.

Oh! imagine their delight. Provisions nearly gone, and nearly six months upon that little lone spot in the midst of this immense ocean. The ship still lies upon the reef, the saddest spectacle I ever beheld, and the surf breaking all over her. They had just finished building a little boat, in which, if successful in getting through the reef, they were about leaving for—they knew not where. I had to leave her behind with her colors flying. My people left on a board on the island an account of the whole affair and by whom they were rescued.

At sea, August 28.—On my way back to Tahiti, having found and taken off from Pitcairn's Island the three men before mentioned. They had given up all hope of relief and gone regularly to work to cultivate the land and try and support themselves. Had a plenty of chickens, goats, fruit of all kinds, and said if they had only had some women they would have stayed there altogether. Our boat came off loaded with such things as I have mentioned in the eating line, and any quantity of books left by the people when they vacated the island. I have two bibles found on the island, and one of them belonging to and having the name of Catherine Christian in it—she being the direct descendant of the principal mutineer of the Bounty. I have also a beautiful little goat, and you would be amused to see it follow Willie around and cry after him already. They had given the captain up as lost and had no idea of any one being near them until the chief mate, whom I sent in the boat, called them by name—they were at work in the field. This whole affair would afford matter for a beautiful little history which many would be disposed to doubt the truth of. The second mate told me that when we were first discovered it was just before dark, raining hard and blowing a severe gale, and the man who saw us was so overcome with joy that he could not speak, threw his hands up, made all sorts of signs, and the tears streaming down his face. He was before the wreck one of the worst men in the ship, but has become really pious; and then came the tug of war to know whether we had seen them and their signals as we hauled off for the night. All night long in suspense and burning fire to attract us, and then at daylight no ship in sight. All, they thought, was over, when again at sunrise we hove in sight—you can imagine their delight.

I have had them all well clothed, and every comfort in the world or in my power bestowed upon them. They had not seen a single sail since their wreck—five months and eighteen days; and not likely they would, as it was a most dangerous place and all vessels would naturally avoid going near it.

Imagine such a fix! Many other vessels, doubtless, have been wrecked there, as spars and such things were found, and the clasp of a navy sword-belt also. Captain Knowles, I trust, ere this, is well on his way homeward to relieve the distress of his poor wife, and how rejoiced he also will be to hear of my success, for I know he thought that many of my crew would be lost in the attempt to take them off. You remember that in my last letter from Panama I said, "If I only save one individual from distress I shall be compensated for all my trouble on this cruise"; forty-three have been certainly saved from starvation and death, and I feel a hundred times repaid. Now that I have left these parts I will tell you the name of the cluster of islands I have been among—Low or Dangerous Archipelago, so dangerous are they considered—all cannibals. I should not be surprised if I have to take these people over to Honolulu, and if so, shall get your letters.

I shall not have provisions enough to keep them all the cruise, and no vessel probably at Tahiti to send them in. But good must certainly result from my cruise to our people out here, and it will take volumes to tell you all I have done and where I have been and passed through. I have fought against governments, restored our people to their homes from whence they have been driven, put them in possession of their property, turned an English consul and captain of a French brig-of-war out from my meetings with the natives for their interference, attacked and burnt towns, killed more than thirty of the savages who had killed and eaten two Americans at the island of Wyia Teegee, had seven of my own men wounded and one officer, made them sue for peace, and saved from starvation thirty-seven of the crew of the Wild Wave, and am taking them to their friends and homes.

The inhabitants of this island have been a terror to the whole group for years—very fierce, perfect cannibals, and so strong as to consider themselves invincible. They have beaten off as many as eight or nine hundred of the other islanders at a time; my party, fifty-four in number, had to attack them in the mountains and bushes, at an elevation of 2500 feet above the sea level. Many of them fainted from heat and fatigue before they reached the top, and without water all the march. But they dashed into action opposed to 500 of these devils incarnate, singing the "Red, White and Blue," and planting the star-spangled banner on the very pinnacle, and laying the town in ashes; these creatures shouting all the while like wild beasts, and fighting them all the way back from behind the rocks and bushes. I have had to take one of my wounded men in the cabin, to save his arm-bone shattered all to pieces. My coxswain was shot through the shoulder, a marine through the foot, another man through the leg, and the chief mate of the Wild Wave, whom I shipped as a master's mate, through the foot. Caldwell commanded the expedition and did wonders, indeed it has been a very gallant little affair. My wounded are all doing well. Our consul says the visit of the ship has been of great service and will be felt for a long time.

The difficulty I had with the British consul and French captain was at Raiatia, and from this cause. The islanders desired to give the islands to the United States, and had a petition to that effect drawn up and sent to our Government. Mr. Consul and Frenchman objected and got up a counter petition from a few; had the other signers, through fear of their governments, turned out of office and to withdraw their names from the first paper, and then insisted upon all Americans being banished from the island, which was done and all of them taken away forcibly by the French captain and carried to Tahiti.

Our consul at Tahiti informed me of this outrage, and I immediately took them back, placed them in possession of their property, and demanded their future protection, and that I would punish them severely if it was not granted.

Mr. Frenchman and John Bull were still there, and insisted upon being present at my meetings, which I objected to and had them turned out.

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

ON THE EFFICACY OF OIL FOR SUBDUING THE VIOLENCE OF BROKEN WATER.

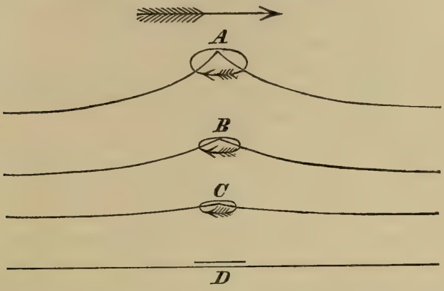
By G. W. LITTLEHALES, U. S. Hydrographic Office.

SECTION I.

THE STRUCTURE OF SEA-WAVES.

It is essential to the just understanding of the best methods for opposing the violence of waves, that the phenomena which constitute wave-motion be understood. It can be said with some degree of confidence that there is no instance in nature of a perfectly quiescent surface of water. Air and water are both mediums of extreme mobility, and the individual molecules of both, and of all other substances, are continually in a state of motion, with different velocities, in paths different in direction and length. There is thus a continual interlacing of particles. When air covers water, some of the particles of air, in their excursions, strike the surface of the water, producing unequal pressures upon it, and giving rise to ripples which the vision is not acute enough to detect. If the original surface of the water were perfectly smooth, and if all parts of it continued equally exposed to an equal wind, waves could not be produced. But, with the minute corrugations which are always present upon the smoothest water, it is to be observed that it does not occur that water is all equally exposed to equal winds. The pressures of the moving air upon the crests and posterior portions of the minute corrugations are greater than those on the hollows and anterior portions. There is thus a tendency to heap up the water at the places of greatest pressure, which is augmented by the rotational or vortex motion produced by the viscosity of the air. These actions produce new forms and inequalities, which, exposed to the wind, generate new modifications of its force and give rise to further deviations from the primitive condition of the fluid. Imagine an isolated example in which the water has been suddenly heaped up by a gust of wind. The action of gravity tends to force this heap to the level of the original surface, which causes the particles of water in the heap to push forward the particles immediately in front of them out of their former place to another place further on, and they repose in their new place at rest as before the original heaping up. Thus in succession volume after volume continues to carry on a process of displacement which only ends with the exhaustion of the displacing force originally impressed and communicated from one to another successive mass of water. As the particles of water crowd upon one another in the act of going out of their old places into the new, the crowd forms a temporary heap visible on the surface of the water, and as each successive mass is displacing its successor, there is always one such heap, and this heap travels apparently at that point where the process of displacement is going on; and although there may be only one crowd, yet it consists of always another and another set of migrating particles. This moving crowd constitutes a true wave. The velocity of the wave is the velocity with which the heap is seen to move. Its form is the form of the heap. Its length is the distance from crest to crest, and its height is the distance from the crest to the surface of the water before the disturbance.

The motions of the individual particles of water are different from the motion of translation which the wave has. Consider a particle in a mass of water about to be traversed by a wave-form. The action of gravity on the heap behind it tends to press it forward where it is confronted by a solid wall of water. Under the action of these two opposite forces the particle is driven upward and forward until the particles which have displaced it have made room for themselves, then it sinks, and finally comes to rest a little in advance of the place from which it started. The motion of migration of each individual particle is thus in a closed orbit. The propagation of the wave is the advancement of a mere form. The actual translation of water in the propagation of unbroken waves is small. The motion of each particle takes place in a vertical plane parallel to the direction of propagation of the wave. The path or orbit described by each particle is approximately elliptic, and, in water of nearly uniform depth, the longer axis of the elliptic orbit is horizontal and the shorter, vertical. When at the top of its path, the particle moves forward as regards the direction of propagation; when at the bottom, backwards. as shown by the curved arrows in the accompanying figure. The straight arrow denotes the direction of propagation.



The particles at the surface describe the largest orbits. The extent of the motion horizontally and vertically diminishes with the depth below the surface. A particle in contact with the bottom of water of moderate depth moves backward and forward in a horizontal straight line as at *D*. On the ocean, where the water is deep as compared with the length of a wave, the paths of the particles are nearly circular, and the motion is insensible at great depths.

When waves are first raised at sea their crests are smooth and rounded, as represented in Fig. 2. As the wind freshens the crests rise higher and become more acuminate. Rankine has investigated the limiting forms which waves assume before breaking, and has concluded that in the steepest possible oscillatory waves of the irrotational kind, the crests become at the vertex infinitely curved in such a manner that a section of the crest by the plane of motion presents two branches of a curve which meet at an angle of $\frac{\pi}{2}$. Some years later Stokes concluded that the two branches of the crest are inclined at an angle of $\pm\frac{\pi}{3}$ to the vertical, and at an angle of $\frac{2}{3}\pi$ to each other, not $\frac{\pi}{2}$ as supposed by Rankine.

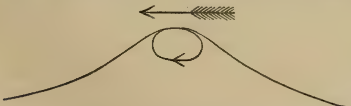


Fig. 2.

After the prolonged action of the wind, when the crests of the waves rise to a considerable height and become sharper and sharper, the passage of the air over the crests with high velocity tends to impart its velocity to them. Owing to the inertia of the lower masses of water, the imparting of this velocity is resisted. The paths of the particles become distorted, as shown in Fig. 3, the front of each wave gradually becomes steeper than the back, and the crests seem to advance faster than the troughs, until at length the front of the wave curls over and breaks, as shown in Fig. 4.

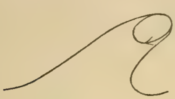


FIG. 3.

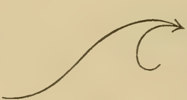


FIG. 4.

Large sea-waves seem to be the result of a building-up process carried on by the joint action of large and small waves. If, for any cause, there be one wave larger than those surrounding it, its size will be continually increased at the expense of the smaller ones. For these smaller waves, in passing over the top of the larger, offer increased obstruction to the wind and cause the formation of cusps when the waves coincide. The delicate equilibrium incident to a cusped form is easily destroyed by the action of the wind, and the crest of the wave breaks into fragments which go to increase the volume of the large wave, leaving the small ones yet smaller. Therefore, whatever influence prevents the breaking of waves acts also as an agency to prevent their increase in size. No fact of observation and no method of sound reasoning has yet led to the conclusion that the spreading of oil on the surface of water agitated by waves can exercise any sensible effect in lessening the size or velocity of the waves themselves. It is in the breaking of the waves that the oil finds its field of action.

SECTION II.

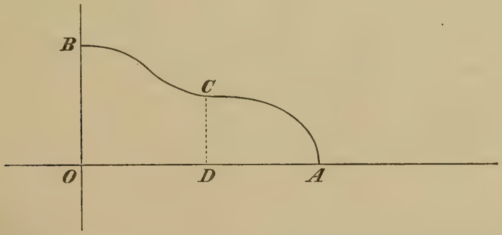
WHY OIL SPREADS OVER THE SURFACE OF WATER.

There is an attraction of one particle of water for another, and there is an attraction of one particle of oil for another, but there is a repulsion between a particle of water and a particle of oil. If we attempt to mix oil and water, the two liquids separate from each other of themselves, and, in the act of separation, sufficient force is brought into play to set in motion considerable masses of the fluids.

Imagine an individual particle of water within a mass of water. The particles on every side of the individual particle attract it, and the attractions of opposite particles on every side tend to neutralize each other, so that the individual particle has almost perfect mobility. The surface particles, however, inasmuch as all the rest of the fluid is below them, are drawn inward toward the mass of the fluid, and a certain tension is produced. This tension is potential energy, and is inherent in the surface particles in virtue of their position. If we consider an oily film spread over the surface of a body of water, it will appear that the particles near the surfaces which separate the oil from the water and from the air must have greater energy than those in the interior of the film. The excess of energy due to this cause will be proportional to the area of the surface of separation.

In a unit of area separating any two fluids, let the energy which the particles have in virtue of the tensions due to their positions, be defined as the *surface energy per unit of area.*

When the area of the surface is increased in any way, work must be done; and when the surface is allowed to contract, it does work upon other bodies. Hence it acts like a stretched sheet of india rubber, and exerts a tension of the same kind.



Let the equation to the curve BCA be $y=f(x)$. Take any ordinate, as CD, whose length is y, and let the whole tension exerted across this line be represented by φ, then the superficial tension is measured by the tension across a unit of length of y, or since φ is the tension across the whole ordinate y, if T, which is constant, is the superficial tension per unit of length, $\varphi = Ty = T.f(x)$. Suppose that the variable ordinate y is originally in contact with the axis OB, and that the surface included between the curve and the two axes is produced by drawing the ordinate y away from the axis OB toward the right by the action of the force φ. If we consider OB and DC, which is equal to y, to be two rods wet with oil and placed between the curve and the axis of X, and then drawn asunder, the oily film $BCADO$ will be formed. Let E represent the superficial energy per unit of area. Then the work done in forming the film will be

$$E \int f(x) \, . \, dx.$$

But if φ is the variable force required to draw the ordinate y from the axis OB, the same work may be written

$$\int \varphi \, . \, dx \, .$$

Therefore

$$\text{Work} = \int \varphi \, . \, dx = E \int f(x) \, . \, dx \, , \qquad (1)$$

$$\varphi = T \, . \, f(x) \, ;$$

substituting the value of φ in (1),

$$T \int f(x) \, . \, dx = E \int f(x) \, . \, dx \, ,$$

or

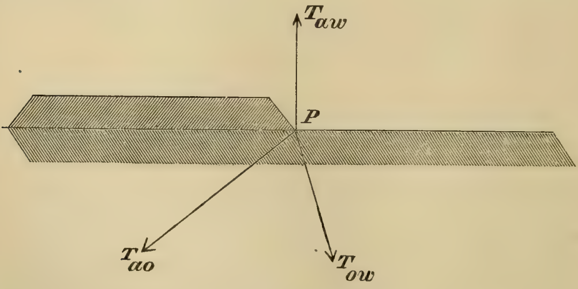
$$T = E \, ,$$

or the numerical value of the superficial energy per unit of area is equal to the superficial tension per unit of length.

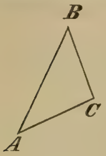
Let T_{ao} represent the superficial tension of the surface separating air from oil.

Let T_{aw} represent the superficial tension of the surface separating air from water.

Let T_{ow} represent the superficial tension of the surface separating oil from water.



Let the figure represent an exaggerated picture of a layer of oil on the surface of a body of water. Let P be a point of the line forming the common intersection of the surfaces separating the air, oil, and water. For equilibrium of these three media, the three tensions T_{ao}, T_{aw}, and T_{ow} must be in equilibrium along the line of common intersection, and since these tensions are known, the angles their directions make with one another can easily be determined. For, by constructing a triangle, *ABC*, having lines proportional to these tensions for its sides, the exterior angles of this triangle will be equal to the angles formed by the three surfaces of separation which meet in a line.



But it is not always possible to construct a triangle with three given lines as its sides. If one of the lines is greater than the sum of the other two, the triangle is impossible. For the same reason, if any one of the superficial tensions is greater than the sum of the other two, the three fluids cannot be in equilibrium in contact.

If, therefore, the tension of the surface separating air from water is greater than the sum of the tensions of the surfaces separating air from oil and oil from water, then a drop of oil cannot be in equilibrium on the surface of water. The edge of the drop where the air meets the oil and the water becomes thinner and thinner till it covers a vast expanse of water.

M. Quinke has determined the superficial tensions of different liquids in contact with each other and with air, and the following is an extract from his table of results. The tension is measured in grams per linear centimeter at 20° centigrade.

Liquid.	Specific gravity.	Tension of surface separating liquid from air.	Tension of surface separating liquid from water.
Water,	1.0000	.08235	.00000
Olive oil,	0.9136	.03760	.02096

Although olive oil is here taken as the representative of oils, it is not considered so well adapted for use at sea as some of the others.

Whale oil seems to be the best adapted for this use, but the surface tensions of this oil do not seem to be determined. It may be presumed that they do not differ greatly from the values given for olive oil.

SECTION III.

HOW BREAKERS LOSE THEIR FORCE THROUGH THE OPERATION OF SURFACE TENSIONS.

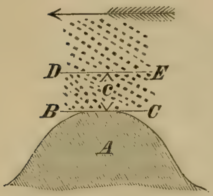
Let us imagine a "break" to occur after the surface of the water is covered by the oily film. For every square centimeter of film torn asunder there will be destroyed .05856 centigrammeter of potential energy, being the sum of .03760 and .02096, the potential or surface energies, in centigrammeters per square centimeter, of the surfaces separating air from oil and oil from water; and there will be generated for every square centimeter of free surface of water formed .08235 centigrammeter of potential energy. Thus the mere act of breaking the film of oil causes an expenditure of energy, because it lays bare a surface having a tension greater than the sum of the tensions of the surfaces separating air from oil and oil from water. But there is a further loss of energy. Suppose, after a "break" has occurred, a layer of water glides over a layer of oil. The superficial energy in the surface separating the oil from the air, amounting to .03760 centigrammeter per square centimeter, is replaced by .10331 centigrammeter per square centimeter, being the sum of .08235 and .02096, the superficial energies per square centimeter of the surfaces separating air from water and water from oil respectively. Therefore, when water breaks over an oily film, there is required for the formation of each square centimeter of a layer of water on the oily film, .10331 minus .03760, or .06571 centigrammeter of work.

SECTION IV.

HOW THE FILM OF OIL ACTS AS A SHIELD TO PREVENT THE DERANGEMENT OF THE WAVE MECHANISM.

It has been pointed out that when waves are propagated across any body of liquid, the individual particles of the liquid describe closed orbits. At the highest points of these orbits, or in the crests of the waves, the particles are moving in the direction of the propagation of the wave. The centrifugal and centripetal forces acting upon each particle are in equilibrium, and, for a unit of mass, are each equal to $\frac{v^2}{r}$, in which $r =$ the radius of the orbit, and $v =$ the velocity of the particle along the orbit.

When the wind is blowing over the waves with a velocity greater than the velocity of propagation, and in the same direction with it, the moving air tends to impart to the particles of water a velocity additional to the normal velocity of revolution in their orbits, causing the distortion of the orbits and the disintegration of the crests of the waves. The force which the moving air exerts to draw the water along with it is due to the viscosity of air. When wind blows over water, all the air does not pass over the surface of the water. On account of the high degree of adhesion between air and water, a thin stratum of air remains in contact with the water, and it is the action of the internal friction or viscosity of air tending to draw this stratum along which causes the tractive effect of wind on water.



In the figure, A represents the crest of a wave, and the dotted area represents the air above it. Let BC represent the stratum of air which remains in contact with the water, and let c, the distance between the horizontal planes BC and DE, be the thickness of the layer of air which undergoes shearing strain when the velocity of the wind relatively to the velocity of propagation of the waves is V. The air at the height of the plane DE will then be moving relatively to the water with a velocity V, while the velocity of any intermediate stratum will be proportional to its height above BC. The rate at which shearing strain is increasing in the area between the planes DE and BC is measured by the velocity of the upper plane divided by the distance between the planes, or by $\frac{V}{c}$.

Let the direction of the arrow denote the direction in which the wind and waves are moving. Let F denote the shearing stress, which is measured by the horizontal force exerted by the air on a unit of area of the plane BC, and acting from C toward B. The ratio of the force to the rate of increase of the shearing stress is called the coefficient of viscosity, and is generally denoted by the symbol μ. We may therefore write:

$$F = \mu \frac{V}{c} \qquad (1)$$

Maxwell has determined μ for air at $\theta°$ centigrade to be

$$\mu = .0001878\,(1 + .00366\ \theta°) \qquad (2)$$

the centimeter, gram, and second being units. So that

$$F = .0001878\,(1 + .00366\,\theta°)\,\frac{V}{c}. \qquad (3)$$

If R is the amount of this force on a rectangular area of length a and breadth b,

$$R = abF = .0001878\,(1 + .00366\ \theta°)\,\frac{ab\,V}{c}. \qquad (4)$$

Suppose the velocity of propagation of the waves to be 15 miles per hour, and the velocity of the wind to be 40 miles per hour, and that the thickness of the stratum undergoing shearing strain is 5 feet, and that the temperature is 20°. Then $V = 40 - 15 = 25$ miles per hour $= 42$ feet or 1280.15 centimeters per second, $c = 5$ feet $= 152.4$ centimeters, and $\theta^\circ = 20^\circ$. The force exerted on each square centimeter of the crest of the wave would be $.0001878(1 + .00366 \times 20^\circ)\frac{42}{5} =$ .0017 gram.

In the above case, if the height of the wave be 10 feet and its length 300 feet, we have, from the following proportion which obtains in oscillatory wave-motion,

$$\frac{\text{mean speed of particle}}{\text{speed of wave}} = \frac{\text{circumference of particle's orbit}}{\text{length of wave}},$$

mean speed of particle $= 2.6$ feet per second $= 79.25$ centimeters per second.

There is thus, according to these moderate suppositions, a force of .0017 gram acting upon each square centimeter of a surface directly connected with a system of particles moving in the direction in which the force is exerted with a velocity of 79.25 centimeters per second. When a film of oil is spread over the surface of the water, this tractive force is not brought to bear on the surface of the water as long as the oily film remains unbroken, but acts upon the surface of the film, whose particles, being entirely separate from the particles of water, do not share their motion. The surface of the water is thus shielded from the action of the wind in the same manner as if a skin of india-rubber were spread over it, and the only action of the wind in this case is to move the film over the surface of the water with a force equal to $\mu \frac{V}{c}$ upon each square centimeter of surface.

SECTION V.

THE ACTION OF A FILM OF OIL TO PREVENT THE GROWTH OF WAVES AND THE FORMATION OF SHARP CRESTS.

The following passage, illustrating the mode of the formation of sea-waves, is taken from the Report on Waves, made to the British Association for the Advancement of Science, in 1842 and 1843, by John Scott Russell, M. A., F. R. S.:

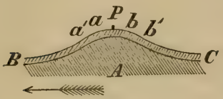
"An observer of natural phenomena who will study the surface of a sea or large lake during the successive stages of an increasing wind, from a calm to a storm, will find in the whole motions of the surface of the fluid, appearances which illustrate the nature of the various classes of waves . . . . and which exhibit the laws to which these waves are subject. Let him begin his observations in a perfect calm, when the surface of the water is smooth and reflects like a mirror the images of surrounding objects. This appearance will not be affected by even a slight motion of the air, and a velocity of less than half a mile an hour (8½ inches per second) does not sensibly disturb the smoothness of the reflecting surface. A gentle zephyr flitting along the surface from point to point may be observed to destroy the perfection of the mirror for a moment, and on departing, the surface remains polished as before; if the air have a velocity of about a mile an hour, the surface of the water becomes less capable of distinct reflection, and on observing it in such a condition, it is to be noticed that the diminution of this reflecting power is owing to the presence of those minute corrugations of the superficial film which form waves of the *third order*. These corrugations produce on the surface of the water an effect very similar to the effect of those panes of glass which we see corrugated for the purpose of destroying their transparency, and these corrugations at once prevent the eye from distinguishing forms at a considerable depth, and diminish the perfection of forms reflected in the water. To fly-fishers this appearance is well known as diminishing the facility with which the fish see their captors. This first stage of disturbance has this distinguishing circumstance, that the phenomena on the surface cease almost simultaneously with the intermission of the disturbing cause, so that a spot which is sheltered from the direct action of the wind remains smooth, the waves of the third order being incapable of travelling spontaneously to any considerable distance, except under the continued action of the original disturbing force. This condition is the indication of present force, not that which is past. While it remains it gives that deep blackness to the water which the sailor is accustomed to regard as an index of the presence of wind, and often as the forerunner of more.

"The second condition of wave-motion is to be observed when the velocity of the wind acting on the smooth water has increased to two miles an hour. Small waves then begin to rise uniformly over the whole surface of the water; these are waves of the *second order*, and cover the surface with considerable regularity. Capillary waves disappear from the ridges of these waves, but are to be found sheltered in the hollows between them, and on the anterior slopes of these waves. The regularity of the distribution of these secondary waves over the surface is remarkable; they begin with about an inch of amplitude, and a couple of inches long; they enlarge as the velocity or duration of the wave increases; by and by conterminal waves unite; the ridges increase, and if the wind increase, the waves become cusped, and are regular waves of the *second order.* They continue enlarging their dimensions, and, the depth to which they produce the agitation increasing simultaneously with their magnitude, the surface becomes extensively covered with waves of nearly uniform magnitude."

Observation has thus shown that, in the generation of oscillatory waves, ripples or capillary waves are first formed, and that it is to the union of conterminal ripples and to their more abundant formation with the increased force of the wind that the growth of waves is due. The existence of a certain definite tension, equal to .08235 gram per linear centimeter, at the common surface of air and water has been pointed out. The water surface under this tension is in perfect equilibrium.

When wind blows over the surface of a body of water, the tangential force which the air, in virtue of its viscosity, exerts on the surface of the water is of different degrees of intensity at different places, owing to the minute corrugations which are always present on the surface of a body of water, and to the eddying motion of the air. At the places where the tangential force is greatest, the surface film of water is drawn along and heaped upon the portions of the surface immediately in front of them, destroying their surface tension or energy of position, and, by laying bare new surface in the places from which they are moved, generating a like amount of surface tension. Through this action heaps or ripples are formed, and surface tension is being constantly generated and destroyed. The formation of ripples takes place on waves already in existence in the same manner as upon a surface of water originally at rest, and by continually uniting with the larger waves, they impart those dangerous qualities to the wave which result from high and acuminate crests.

When a film of oil is spread over the surface of the water, this heaping-up action, which, in the case of the water film, results in the formation of ripples, cannot take place. This has been demonstrated by the experiments of Mr. John Aitken, described in the Proceedings of the Royal Society of Edinburgh, Vol. XII, 1882–83, No. 113.



Let *A* represent the crest of a wave covered by the film of oil *BC*, and let *P* be a point of greatest action of the tangential force of the wind, which is supposed to move in the direction of the arrow. The tendency of this action is to drive the film into a heap immediately in front of *P*. By this action, a greater tension is generated in the film at *b* and a lesser tension at *a*. The greater tension at *b* tends to draw the portion at *b′* ahead, and the lesser tension at *a* allows the tension at *a′* to draw the portion at *a* ahead. So that, instead of a tendency toward heaping up, there is a tendency to move the entire surface film along at a uniform rate. The formation of ripples is therefore stopped, and the growth of the waves and the formation of "breaking" crests, as far as they result from this cause, are prevented.

PROFESSIONAL NOTES.

THE THURLOW CAST-STEEL GUN.

The Act of Congress of March 3, 1887, appropriated $20,400 for three rough-bored and turned cast-steel 6-inch guns, and under the proposals of the Navy Department two guns were received.

The first, the Pittsburg gun, of Bessemer steel, tempered, was proved at Annapolis, December 5, 1888. Its fate is well known, it having burst into numerous fragments at the first round, with service charge of 48¼ pounds of brown powder.

The Thurlow gun was cast of open-hearth steel, untempered, weight 13,100 pounds. The results of the physical tests made at Washington are as follows:

Specimen.	Tensile strength per square inch. Pounds.	Elastic strength per square inch. Pounds.	Elongation after fracture. Per cent.	Reduction of area after fracture. Per cent.
Muzzle: Longitudinal,	80,468	37,942	20.60	23.26
Transverse,	80,570	38,961	18.20	30.12
"	81,334	38,451	18.50	27.40
Breech: Longitudinal,	80,519	38,961	19.55	24.31
"	80,977	38,451	19.10	27.40
Transverse,	80,162	37,942	20.65	22.56
"	79,246	36,414	24.75	32.43
"	79,309	37,072	27.85	40.78

The contour of the gun is a smooth curve, following in a general way the form of the built-up gun of the same caliber, but not showing its abrupt changes of exterior diameter. The trunnion band is screwed on. The exterior diameter over the powder chamber is 22.2 inches, and the diameter of the chamber at a corresponding point is 7.5 inches. Computing the pressure which the gun will endure at this point without being permanently deformed, using the highest elastic strength given by the tests, we find it to be, by Virgile's formula, 13.8 tons per square inch. Using Clavarino's formula, which gives a result probably much nearer the truth, we find the elastic strength of the gun at the same point to be 11.2 tons. The ordinary service pressure for 2000 f. s. initial velocity is 15 tons per square inch, and this pressure may be as much as doubled by an accident, such as the deformation of a weak shell in the bore, or by the powder becoming unduly quick owing to long exposure to a high temperature in a cruising vessel.

Computing the bursting pressure by Clavarino's formula, using the highest tensile strength given, we find it to be 23.2 tons.

Before firing, the polished surface of the chamber showed a discoloration which had the appearance of a flaw, but the star gauge showed no difference of diameter, and there was no other appearance of any flaw.

The statutory test of ten consecutive rounds with service charges, fired as rapidly as possible, took place February 7, 1889. The gun had been carefully star-gauged, and the gauge laid away without breaking joints. Two rounds of 36 pounds were fired for the purpose of fitting the gas-check pad, and then ten rounds with a charge of 48¼ pounds Dupont's O. P. C. brown pierced prismatic powder and a shell of 100 pounds. This charge in the 6-inch gun gives a pressure of 15 tons.

An examination of the bore revealed several flaws: near the seat of the shot, 5 feet 4 inches from the face of the breech, a flaw extending across the fifth band and groove to the right from the bottom of the bore; at 58 inches from the breech, a small flaw across the third and fourth bands to the left; at 58 inches, one extending across the tenth and eleventh bands to the left. The star gauge showed enlargements as follows:

Distance from face of breech. Inches.	Enlargement. $\frac{1}{1000}$ of inch.
49.00	13
49.25	11
49.50	10
49.75	9
50.00	9
51.00	8
52.00	8

From a point 52 inches from the breech the enlargement gradually decreased at the rate of about .001 per inch, until at 90 inches it was practically nothing.

Such a result was to be expected from the calculated elastic strength of the gun. The contract required that it should not exhibit defects or weakness under the statutory test. None of the built-up guns have ever shown any enlargement under the statutory test, or under the abnormal pressures sometimes developed in experimental firing, and they have so large a factor of safety under present conditions that the Chief of Bureau contemplates obtaining from them a higher muzzle velocity with increased working pressure.

C. S.

SPRENGEL'S EXPLOSIVES.

[Translated from *Wagner's Jahres-Berichte der Chemie und Technologie*, Vol. 20, 1874, by Karl Rohrer, Lieutenant, U. S. N.]

Note.—Enough time seems to have elapsed since these explosives were really discovered and given to the world for them to have disappeared, to a considerable extent, from the public memory, and in consequence of this fact they are being rediscovered in this country, England, Germany and other countries, and offered to the ordnance authorities of the day as something likely to revolutionize modern warfare. To refresh my own and the memory of the service I have made this translation.

Herman Sprengel has published a lecture upon a new class of explosive bodies which, during their fabrication, storage and transportation, are non-explosive, from which we extract the following:

With the object of discovering improved and other means for producing explosions than those already known and in use, the author observed the effect of a detonator upon numerous mixtures of explosive and combustible bodies. The components of the mixtures were proportioned in such a way that, theoretically, they should be perfectly oxidized and deoxidized. In the experiments, the author used steel and Brown's patent detonator, which consists of a conical metal tube of about the strength of a goose-quill, is 5.6 cm. long and contains .65 grm. fulminate of mercury. Such a detonator was connected with the end of a safety-string fuze, commonly used in blasting; and the detonator, so connected and encased in a thin glass tube, was placed in the midst of the mixture whose explosiveness was to be determined. By igniting the free end of the string-fuze, the fulminate of mercury was presently caused to detonate, shattering its encasing tube and exerting its power upon the explosive charge of from 20 to 100 grm. contained in an open, wide-mouthed glass bottle.

As among the oxidizing agents which come into consideration, nitric acid, HNO_3, contains the greatest quantity of oxygen disposable for combustion, *i. e.* 63.5 per cent ($\frac{5}{6}$ of its entire oxygen, which is 76.2 per cent), this body especially attracted the attention of the author. He found by experiment that under certain conditions, if any one of a number of organic substances was dissolved in nitric acid of about 1.5 sp. g., it became susceptible to explosion by detonation.

The hydrocarbon class furnishes the most suitable combustible substances which may be dissolved by nitric acid; as, however, when treated by the latter there ensues a violent chemical reaction, attended with great heat development, necessarily resulting from the formation of the nitro-compound, it is preferable, therefore, to dissolve this compound itself in nitric acid. If, for example, phenol (carbolic acid) is mixed with nitric acid, without the necessary precautions against accident, then the temperature of the mixture rises rapidly to the firing point. If, however, phenol, after treatment with nitric acid, that is, trinitrophenol (picric acid) is treated with nitric acid, the temperature falls, and to such an extent that this mixture may be used for refrigerating purposes.

It is extremely instructive to subject these mixtures and other well known explosive bodies, as gun-cotton and nitroglycerine, to a comparative analytical study. We submit the following in this connection:

(1). Nitrobenzol, $C_6H_5(NO_2) = 28.08$
Nitric acid, $5(HNO_3) = 71.92$
100.00

Elementary composition before explosion.	Probable composition after explosion.
$C = 16.44$	$CO_2 = 60.27$
$H = 2.28$	$H_2O = 22.55$
$N = 19.18$	$N = 19.18$
$O = 62.10$	
100.00	100.00

(2). Trinitrophenol (picric acid), $C_6H_3(NO_2)_3O = 58.3$
Nitric acid, $2\frac{3}{5}(HNO_3) = 41.7$
100.00

Elementary composition before explosion.	Probable composition after explosion.
$C = 18.33$	$CO_2 = 67.20$
$H = 1.43$	$H_2O = 12.83$
$N = 19.97$	$N = 19.97$
$O = 62.27$	
100.00	100.00

Gun-cotton, $C_6H_7(NO_2)_3O_5$.

Elementary composition before explosion.	Probable composition after explosion.
$C = 24.24$	$CO_2 = 55.52$
$H = 2.36$	$H_2O = 21.24$
$N = 14.14$	$N = 14.14$
$O = 59.26$	$C = 9.10$
100.00	100.00

Trinitroglycerine, $C_3H_5(NO_2)_3O_3$.

Elementary composition before explosion.		Probable composition after explosion.	
$C =$	15.85	$CO_2 =$	58.18
$H =$	2.20	$H_2O =$	19.80
$N =$	18.50	$N =$	18.50
$O =$	63.45	$O =$	3.52
	100.00		100.00

These analyses prove that the new mixtures do not leave any inert residue—neither carbon, as gun-cotton, nor oxygen, as nitroglycerine, though in reality the decomposition does not take place so simply as is here indicated. It is evident that the elementary constitution of these mixtures may be variously modified, while the elementary constitution of chemical combinations is fixed and unalterable. By increasing or decreasing the quantity of the hydrocarbon it is possible to utilize all the oxygen for combustion and so produce carbonic oxide or carbonic acid, or a mixture of these two gases; in other words, to produce more gas and less heat, or less gas and more heat, as may be done, for example, in the case of powder by changing the proportion of charcoal.

The mixture of nitrobenzol and nitric acid in the preceding proportions explodes with intense violence when fired by a detonator. Nitrobenzol dissolves readily in nitric acid, and if the solvent is weakened by water to 1.42 sp. g. is again precipitated. Upon mixing the two substances, at first there is development of heat; therefore when working with considerable quantities, some cooling arrangement will be required. In mixing 25 cubic centimeters the author observed increase of temperature to 50° C. By employing dinitrobenzol the temperature would probably fall. This mixture has the appearance of nitric acid, though the addition of 28 per cent of nitrobenzol to the acid appears to make it less volatile and less hygroscopic. Absorbed by infusorial earth and thoroughly incorporated with it, the mixture burns with a pale flame like dynamite, but not so lively. No inclination to explode was noticed while burning. The author found it very difficult to explode by concussion or shock, to do which he enclosed pellets of it in tinfoil and struck them upon an anvil. Gun-cotton and Nobel's dynamite, similarly treated, exploded upon receiving a materially weaker blow. The explosion of 35 grm. of the fluid mixture, contained in an open bottle, placed upon a wrought-iron plate of 6.5 mm. thickness, without tamping, made a deep indentation therein, the edges jagged. The explosion of a 35-grm. disk of gun-cotton upon another part of the plate produced an indentation with smooth edges and of less depth. Equal quantities (35 grm.) of the nitrobenzol mixture, gun-cotton and nitroglycerine, exploded upon fir plank of 7.6 cm. thickness, produced about equal results. The wood was cut through and splintered. It is to be regretted that as yet no exact method exists of comparing or measuring the force of detonating explosive bodies.

The following considerations led the author to believe that these new acid explosives would excel all heretofore known explosive bodies in development of force. As in the nitrobenzol preparation we are constrained to regard 5 atoms of the contained oxygen as not disposable for combustion, or already combined with the hydrogen of the nitric acid in the form of water, and as 3 molecules of the oxygen contained in the nitroglycerine, derived from the glycerine, (a triatomic alcohol) may be regarded in the same way, it follows that in the nitrobenzol mixture there remains 52.97 per cent, and in the nitroglycerine 42.3 per cent of oxygen for combustion, of which, however, owing to scarcity of combustible in the latter, only 38.77 per cent can be utilized. As the potential energy (or capacity for work) of a developed heat from a combustion process, and the quantity of oxygen consumed therein are mutually related, one may perhaps be permitted to regard the foregoing figures as a rough measure of the force of the two explosives in question. Therefore the author assumes that the force of nitroglycerine bears the relation to that of the nitrobenzol mixture as 38.77 : 52.97 or 100 : 136.6. If 1 molecule or 2 parts by weight of dinitrobenzol, and 4 molecules or 3 parts by weight of nitric acid, are taken, then the quantity of oxygen disposable for combustion in the mixture rises to 53.3 per cent.

How this and the other preparations will comport themselves when they are stored after their ingredients are mixed, the author is not able to state, as he made his experiments with them soon after mixing. Their ability to be exploded appears to be destroyed by the addition of a small quantity of water. At least he could not explode the nitrobenzol mixture under the above stated conditions when the nitric acid used in its preparation contained less than 25 per cent of the monohydrate. Confining the charge in a small space and employing a more powerful detonator might, perhaps, produce explosion when a more dilute acid was used. The high specific and latent heat of water, which would absorb the heat freed at the commencement of the explosion of the detonator, may account for this lack of explosiveness. The author cannot forbear to connect the remarkable explosiveness of fulminate of mercury with the fact that the specific heat of mercury is only one-thirtieth part of that of water. Fulminate of mercury contains 70 per cent of mercury. R. Bunsen observed, while gradually diluting explosive gas mixtures with non-combustible gases, that the explosiveness or inflammability of these mixtures suddenly ceased at a well defined limit or boundary.

Picric acid, to 58.3 parts, is readily soluble in an equivalent quantity of nitric acid, 41.7 parts. During the process of solution the temperature sinks below the freezing point. As the preceding mixture, so this explodes with great violence when fired by a detonator. Exclusive of the sixth part of the oxygen of the nitric acid, and that due to the phenol, there still remains 50.92 per cent disposable for combustion. It may be appropriate to say here that picric acid itself contains an oxygen mixture which is sufficient to make it a powerful explosive without addition of other oxidizing agent, and that it develops tremendous power when exploded by a detonator. Upon its explosion no smoke is formed. To show the intense heat which is developed upon the combustion of these mixtures, the author states this fact: a machine-made metallic cartridge case of 4.8 cm. length, 1.3 cm. diameter, and 11.4 grm. weight was charged with .65 grm. sporting powder and 1.3 grm. sand, which was moistened with scant .65 grm. of the solution of picric in nitric acid, the moistened sand coming after the powder, and a ball coming last. The cartridge so charged was at once placed in the cold bore of a Martini-Henry breech-loader and fired. Upon withdrawing the cartridge case it was found that the upper half of it had lost its shape entirely, the metal having been melted, and the particles of sand remaining were vitrified.

Instead of the two mentioned, there is a large number of combustible substances which may be used. It is not absolutely necessary that there shall be entire solution. The author succeeded in producing an explosive preparation by adding 17.4 parts of naphthaline to 82.6 parts of nitric acid of 1.5 sp. g. The mixture was of about half fluid consistency.

The author believes that his acid explosives must excel all other explosive bodies of this class thus far known, in the development of force. He rests his claim upon the consideration of the quantity of oxygen disposable for combustion which they contain. The nitrobenzol mixture contains, exclusive of the 5 atoms going to the hydrogen of the nitric acid, 52.97 per cent of oxygen; the picric acid mixture contains, if $\frac{1}{6}$ of the oxygen of the nitric acid and that due to the phenol in the picric acid are excluded, 50.92 per cent of oxygen; nitroglycerine, however, if the 3 atoms of oxygen of the glycerine are excluded, contains only 42.3 per cent of oxygen, of which, owing to lack of sufficient combustible, only 38.77 per cent can be utilized.

The selection of an oxidizing agent is much more limited than that of a combustible body, that is, if complete transformation into gas is insisted upon. Among the former, nitrate of ammonia may be next considered, as it is composed of 35 parts nitrogen, 45 parts hydrogen, and 20 parts oxygen. Unfortunately, this salt is very hygroscopic, otherwise it could be used as an addition to or substitute for nitrate of potassium. The difficulty might be overcome by the use of air-tight cartridges and incorporating a non-volatile hydrocarbon as combustible for the 20 parts of oxygen. The author found that by addition of nitrate of ammonia to sporting powder there was a decided increase of initial velocity of the projectile, as follows:

Weight of sporting powder.	Weight of added ammonium nitrate powder.	Weight of projectile.	Initial velocity per second.
4.92 grm.	....	31.49 grm.	410 meters.
3.69	1.23 grm (*a*)	31.49	431.5
2.46	2.46 (*b*)	31.49	452.2

(*a*) consisted of $100HN_4NO_3 + 7.5$ lampblack.

(*b*) consisted of $80HN_4NO_3 + 15$ charcoal of red dogwood (*Cornus sanguinea*, *L.*).

The ammonium powder was thoroughly mixed with the sporting powder before filling the cartridges; a little of the latter was reserved and scattered about the percussion cap.

Nitroglycerine may also be used as an oxidizing agent, as it contains a surplus of 3.52 per cent of oxygen, by adding a certain proportion of combustible. As free acid in nitroglycerine is the probable cause of terrible accidents, and is to be carefully avoided, therefore if, for example, aniline be added, which is readily soluble in nitroglycerine, a double advantage will be realized, as the aniline will neutralize the acid set free by gradual decomposition, and will also utilize the excess of oxygen contained, and so increase the explosive force of the body.

If we renounce the attempt to achieve complete gasification, we may turn to those explosive bodies whose oxidizing agents are salts of non-volatile bases. Of these, chlorate of potassium is especially observable. This salt yields explosive mixtures united with any one of almost all organic substances. As the mixing of it with combustible substances is a dangerous operation, the author employed fluid ones to avoid friction in mixing. These fluids were brought into contact with porous cakes or lumps of potassium, and absorbed by them quietly and without danger. Such lumps or cakes are obtained by pressing the moistened salt in suitable forms, which, upon drying, have about the consistency of loaf-sugar, and are more or less porous according as the salt is fine or coarse and whether the pressure is great or small. The author exploded detonators containing .65 grm. fulminate of mercury upon cakes so made and treated, without exploding them, and with this means he did not succeed in exploding them until the fluid combustible in the cake was impregnated with a certain proportion of sulphur or nitro-compound. Thus, for example, they exploded very violently upon adding a proportion of bisulphide of carbon; very violently upon adding a proportion of nitrobenzol; violently upon adding a proportion of ½ benzol + ½ bisulphide of carbon; violently upon adding a proportion of bisulphide of carbon saturated with naphthaline; very well upon adding a proportion of phenol dissolved in bisulphide of carbon; well upon adding a proportion of ¾ petroleum + ¼ bisulphide of carbon; not well upon adding a proportion of petroleum saturated with sulphur; not well upon adding a proportion of benzol saturated with sulphur.

If the decomposition of the bisulphide of carbon mixture proceeded in the order of the equation $2(KClO_3 + CS_2 = 2KCl + CO_2 + 2SO_2)$, then 100 parts chlorate of potassium would require 31 parts bisulphide of carbon. The author, however, secured better results by using a smaller quantity of the latter, 15 to 20 parts, as then, upon decomposition, sulphuric acid was formed.

Upon using such a mixture in a granite quarry, it proved itself about four times as powerful as an equal quantity of blasting powder.

Although the simple, sulphur-free benzol mixture did not explode under the mentioned circumstances, it may be assumed, because of the similarity between concussion and detonation, that a body which is explosible by the former may also be exploded by the latter means, if strong enough initial effort is had. The author found, in fact, that when the detonator was surrounded with gun-cotton he could explode chlorate of potassium mixture, which contained neither sulphur nor nitro-compounds, as when mixed with benzol, petroleum, or phenol. Mixtures of this kind, in the form of 80-grm. cakes, placed upon a support in air, exploded with great development of power when the author acted upon them by the detonation of 15, 8, or 7 grm. of gun-cotton. The practical inference from these facts is apparent.

In these, as in the acid mixtures, many combinations and changes are possible and permissible. The chlorate of potassium can be partially, perhaps wholly replaced by nitrate of sodium. Instead of the indicated hydrocarbon, there may be used partially or entirely such as are non-volatile ; even fats, bitumen, resin, and other rigid ones may be used, which have so low a melting point that it is practicable to saturate cakes of the oxidizing salt with them while in the melted state.

Objections to the use of several of the explosive bodies referred to can reasonably be made. The acid explosives are hygroscopic and very difficult to handle and manage because of the corrosiveness of the nitric acid. Further, it is not easy to find a suitable material for cartridge cases ; the choice would be between glass, stoneware, and iron, and if the explosive is prepared for use in the form of dynamite, paper might answer. In respect to cheapness, effectiveness, safety, and reliability, these explosives compare favorably with all others now employed. The oxidizing agents in cake, lump, or granulated form, when impregnated with oily fluids, are protected against the injurious effects of water. The facts must not be lost sight of that about nine-tenths of all explosives produced, powder included, find their field of usefulness in blasting operations, and that the valuable and peculiar property which powder possesses as a propelling agent is not necessary in mining or blasting, as in this field we need, with few exceptions, the most powerful and at the same time the cheapest force. Upon these facts is based the author's hope of a future for the explosives under discussion.

Finally, and this may not be the least advantage possessed by these new explosive bodies, we may, to avoid danger during fabrication, storage, and transportation, keep the oxidizing agent separated from the combustible until such time as it is desired to have them act upon each other and to be made ready as an explosive body. This, of course, is easier of accomplishment when both agents are fluid, or at least one is so, than when both are rigid.

GUN-COTTON.

ITS MILITARY APPLICATIONS, WITH SPECIAL REFERENCE TO THE LATEST DISCOVERIES RELATING TO GUN-COTTON SHELLS.

By MAX VON FÖRSTER, Premier-Lieutenant a. D., Technical Director of the Gun-Cotton Factory of Wolff & Co., Walsrode.

[Translated, by permission of the author, by JOHN P. WISSER, U. S. Army.]

The gun-cotton factory of Wolff & Co., Walsrode, prepares compressed gun-cotton for military use. Although the quality, *i. e.* the chemical composition and the chemical properties, remains constant, the form of the gun-cotton varies with its application.

The principal applications are:

I.—For Stationary Submarine Mines.

For this purpose are largely used six-sided prisms, ¼ kg. in weight, with which any mine receptacle may be filled; or the receptacles for the charge, which are usually cylindrical in form, are filled with masses of gun-cotton of forms specially constructed for this purpose, which together exactly reproduce the interior form of the receptacle for the charge. In the first case the prisms are introduced separately in the mine; the opening for charging may therefore be small. In the second case the entire charge, collected in the receptacle therefor, is introduced at one and the same time into the mine; the opening for charging must therefore be large.

II.—For Movable Submarine Mines (Fish Torpedoes).

We fill the interior of the torpedo-head with gun-cotton, exactly corresponding to the interior space, bring the head up to a definite weight (which must be given us) and solder it up. In order to enable us to do this, all heads should, if possible, be sent to the factory *in natura*.

When this is not practicable, we prepare for the transportation and preservation of the gun-cotton special sheet-zinc vessels having the form of the torpedo-heads, and ship therein the charge.

The main mass of the gun-cotton used for mines and torpedoes is invariably wet, containing 15–25 per cent of water, as may be ordered; the priming charge consists of dry gun-cotton, from ½ to several kg. in weight, as may be required. The dry gun-cotton is always packed separately from the wet. The dry gun-cotton is detonated by means of a detonating primer filled with mercuric fulminate.

III.—For Shells, as Explosive Charge.

The principal kinds of such shells are:

1. *Steel torpedo shells with thin walls and cast-iron shells.*—We furnish new shells, or simply charges for such as are now on hand in the magazines and are to be adapted to gun-cotton. They are useful against objects of slight resistance; and in case of bomb-proof covers, such as casemates, powder magazines and hollow traverses, which are all covered with a considerable thickness of earth, they will pass through the latter, explode on the arches and act by their large bursting charge. The fuze is generally in the mouth. The shells are adapted to rifled mortars and howitzers.

2. *Steel torpedo shells with thick walls and massive points.*—The fuze is in the base (new fuze construction). These shells offer, besides the advantages of the shells under 1, the additional and most important advantages in that

a. On account of their strong walls and their construction, they may be fired not only from mortars, but from all guns, with however high an initial velocity, even above 600 m.

b. By their greater weight, their permanence and their massive points, they are capable of penetrating resisting objects such as granite masonry and cement arches; they therefore possess the immense advantage over the shells with a head-fuze under 1, that the bursting charge will explode and exert its effects *not in front of* the resisting objects, *not on their exterior*, but *within* the objects themselves. The bursting charge will therefore often have ten times the effect of the shells under 1.

The penetration of the shells in hard objects is rendered possible not only by their indicated properties, but also by our new base fuze applied to them, which, even when the shells are fired with the highest initial velocities and against the most resisting objects, does not break or explode prematurely, but acts with regularity, and allows the delay in the action of the fuze, for which it was set, to come into play.

3. *Steel armor-plate shells.*—Not so long as the shells under 2, with massive points, very thick walls, and therefore with but little space for the exploding charge.

Our explosive gun-cotton is, however, so strong that the necessarily small bursting charge is still capable of breaking the bottom and side walls of the shells into many small pieces, while the point remains in one piece, or is divided into but two or three parts, so that after the shell has pierced the plate, by means of the former excellent effect will be obtained against the men and the weak parts of the machinery in the interior of a battery, an armored ship, etc., and by means of the latter more energetic action against the strong parts of machinery.

As is well known, the charge of steel armor-plate shells has been entirely abandoned of late years, because it had been observed that it or the fuze, on account of the sudden shock, caused the armor-plate shell to burst before it had used up all its living force, and thus diminished its action. We have made possible again the use of a bursting charge in the armor-plate shell by means of our explosive and our new fuze, and therefore have again prepared a *shell* for these purposes. The shell had, so to speak, become a solid shot; it no longer burst, and the action of such a projectile, as is well known, is but slight.

Our explosive, in our special mode of application and our new fuze, will endure the greatest shock at the object struck without premature explosion, and will act with regularity and certainty.

Besides all the advantages thus far given, our explosive and this fuze insure the certainty that dangerous bore explosions, even with the highest initial velocities, are effectively excluded, which property allows the applicability of gun-cotton shells in casemates or on board ship and in other confined spaces rendered especially dangerous by explosion taking place in them. We call especial attention to our fuze (base fuze). (See further on.)

Instructions for Charging Shells with Compressed Gun-Cotton.

A. *Charging cast-iron or steel shells which are in a single piece and have the fuze in the head of the shell.* (*Wolff and Co.'s and Von Förster's system.*)

1. *Description of the gun-cotton and the mode of packing it, its transportation and preservation.*—The gun-cotton is in the form of elongated grains, the cross-section of which is a rectangle of 10 to 18 mm. length of side, and their length is 25 to 50 mm. The grains are coated with a thin but compact layer of dissolved gun-cotton obtained by immersion in acetic ether. This layer prevents the crumbling and pulverization of the grains during transport and handling. The gun-cotton which is used for charging shells contains as a rule 20 per cent of water, but there is nothing to prevent the use of such as has but little water. The water renders the gun-cotton incombustible and not sensitive to even the most violent shocks, and the gun-cotton can be detonated only by a fuze specially arranged for the purpose.

Gun-cotton is, therefore, a substance which can be called an explosive only when in the hands of persons who have special charge of it and are in possession of the necessary means of ignition.

Wet gun-cotton, as regards its transportation, preservation and manipulation, is perfectly free from danger, and dry gun-cotton, properly handled, is also perfectly safe in these respects. Dry gun-cotton is not dangerous to store, and, in case it is set on fire by a fire from without, will not explode, if properly packed according to our method. Dry gun-cotton is therefore considerably less dangerous than gunpowder.

The gun-cotton is packed in wooden chests containing interior cases of sheet zinc. The latter are air-tight and prevent the evaporation of the water of the wet gun-cotton, or the absorption of moisture by the dry gun-cotton. Every such case has on the upper side an opening, closed with a cover, and serving for filling and emptying. In these chests the gun-cotton is transported and stored, and the chests remain closed as they come, until the gun-cotton is to be used.

As a magazine, any house of whatever construction is suitable, but the most suitable are such as are simple, light, above ground and not moist. Although all danger is excluded, it is preferable on general grounds to place these buildings, in case they contain large quantities of gun-cotton, not nearer, as a rule, to towns than 150 m. A wall about the magazine is superfluous, and in case of an explosion in the magazine is even harmful, since it would serve to confine and therefore strengthen the energy of the explosion.

2. *Charging of the shells.*—The shells are charged with the gun-cotton through the mouth and are filled out with liquid paraffine, which fills all the interstices between the grains themselves, as well as those between the latter and the shell walls, and after solidification makes a solid mass of the grains, whereby, in firing, a shock or the friction of the gun-cotton against the walls of the shell is rendered impossible.

The fuze extends outward beyond the opening and inward into the shell, since it must be in direct contact with the charge in order to be able to detonate it. In order to secure in the interior of the shell a place for the fuze, the charging is conducted as in the case of shrapnel. In introducing the last portion of the charge, and for the introduction of the paraffine, a charging funnel is used quite similar to the truncated cone used in loading shrapnel. The paraffine is mixed with half its weight of Carnauba wax,* and thereby acquires a high melting point, which may rise to 70° centigrade.

In case a smaller proportion of wax is taken, the melting point is lower. The paraffine is melted in the water-bath, or in a vessel over the fire direct. The paraffine does not become heated to a higher temperature than its proper fusing point till nearly all is melted. As soon as this takes place, however, the temperature rises rapidly. The paraffine, ready for introduction, should be heated to + 80°–85° C., and rapidly introduced.

After 20 minutes to ½ hour, according to the size of the shell, the paraffine is cold and the charging funnel is unscrewed. In the interior of the shell a hollow space is left, exactly large enough to receive the fuze. This space is kept open during transportation and handling.

3. *The Fuze.*—The fuze consists of: (1) the fuze proper, as a rule a percussion fuze with safety arrangement and with a percussion cap; (2) the detonating primer; (3) the priming cartridge of dry gun-cotton.

When the shell strikes the object, the percussion fuze acts, the fire of the cap inflames the primer, this detonates the priming cartridge, and the latter the charge.

In case no cause of delay in action is effected in the fuze, the shell bursts immediately on striking, provided the blow be sufficiently strong to bring the percussion fuze into action.

But since a certain amount of penetration of the shell into the object is generally desirable and necessary for its proper action, all our fuzes, unless otherwise definitely ordered, have their action delayed by means of a column of compressed gunpowder.

The charging of the shells, the insertion of the fuze, the loading of the gun are entirely safe.

Explosions in the bore are not to be expected. We have fired several hundred shots from mortars, howitzers and guns, with the usual service charges, without a single dangerous explosion in the bore.

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* Secreted by the leaves of Copernicia cerifera.—W.

In the summer of 1887, in the course of further experiments in Pola in conjunction with the Austrian navy, we fired 50 shots from the 15 cm. gun, of cast-iron gun-cotton fuze shells with 516 m. initial velocity, with good results.

B. *Charging shells which have a movable head or base, and are therefore in two parts.*

These shells are loaded with gun-cotton in the form of disks, corresponding in diameter with that of the interior of the shell.

Since in charging with these disks less interspace is left between the pieces of gun-cotton than in charging with granulated gun-cotton, the weight of gun-cotton required is some 25 per cent higher.

With reference to the transportation and storage of gun-cotton, as well as the charging of the shells and the loading of the gun, everything, unless special constructions are required, is the same for disk-charging as for granule-charging.

SHELLS WITH BASE FUZE.

Shells with a fuze in the head are capable of penetrating objects not too compact, such as earthen breastworks, earthworks, walls, and woodwork, and, after using up its living force, of acting by its bursting charge.

In objects of great resistance, however, such as armor plates, concrete shields, or granite masonry without earth covering, they cannot penetrate, because they burst immediately on striking the hard object, provided they come with a comparatively great final velocity; the fuze in this case causes a premature explosion.

Although, even under these circumstances, the effect on hard arches, etc., under the earth covering, in consequence of the great detonating power of the gun-cotton, will be quite considerable, it will nevertheless be many times greater than this should the shell be able to penetrate into the hard object, or pass through it and act explosively inside of the covering, *e. g.* in case of a fort, in the interior enclosed with iron or free arches of harder material, or in case of an armored vessel, in the interior of the armored turret or the armored battery.

It is assumed that the shell can stand the shock against the object without breaking. A strong, thick-walled steel fuze shell, as, for instance, the ordinary Krupp steel fuze shell, 4½ calibers long, supplied with a base fuze arranged for the detonation of gun-cotton and a massive point, must be used, or, for firing against strong armor plates, a steel armor shell with a similar fuze.

For these two kinds of shells particularly the author has constructed a base fuze which may also be used for weaker shells, such as cast-iron or thin-walled steel shells, and which possesses the following advantages:

1. It permits of giving the steel torpedo shells and the other fuze shells a massive point, and thereby renders them much more capable of resisting the shock on striking the object.

2. It permits of again giving the steel armor shells a bursting charge (which at the present time has been generally abandoned in the case of these projectiles), as it is so constructed that, even in firing against the most resisting objects, such as armor plates, it does not cause the shell to explode directly on striking the object, as all other fuzes heretofore used do in such cases, but, on the contrary, gives the shell time to penetrate so far into the target as its solidity, its living force and the angle of impact may determine, and only after the time required for this purpose will it cause the charge to detonate and the shell to burst.

It is evident that, when the shell breaks on impact, as is the case when a shell strikes an armor plate obliquely, it cannot penetrate appreciably into the plate, and the explosion will in consequence accomplish little. But, in all firing in time of war, only a small proportion of the shells fired will probably strike the object aimed at, and especially an armor plate, and of these a still smaller number will so strike the plate as to pass through it.

It must therefore be acknowledged that if the shell does not pass through the armor plate the explosion cannot be very effective. Moreover, not only the shell but also its charge will have been wasted. It appears to us, however, that the fewer the shells which will penetrate through the armor plates into the battery within, the more necessary it is to give them the conditions for most effective action, and that, to obtain increased effect, a charge of gun-cotton and our base fuze, after it is proven not to act injuriously, must be adopted for armor shells.

In like manner does our base fuze offer great advantages for other long and short gun-cotton shells, in that it renders them more effective in their action against objects of great resistance. These will include, besides bomb-proof covers of the latest construction, the armored shields, covered with a *béton* or granite layer, of the armored land turrets. We may expect to remove the glacis and then the armored shield, and to fire against the turret itself, and indeed against its exposed under-parts.

3. This new base fuze mainly and effectively excludes all possibility of premature explosions in the bore of the gun which may endanger it.

We may remark incidentally that this base fuze differs essentially from the head-fuze used by us, not only in its properties but also in its construction.

FIRING EXPERIMENTS CARRIED ON WITH THE AUTHOR'S ASSISTANCE.

I. *Firing with gun-cotton shells, carried on by the Royal Italian Land Artillery, on the firing grounds at St. Maurice and in Spezia, in the years* 1886–7.—The object of the experiments was to provide the cast-iron shells of the siege and seacoast guns already on hand, as well as newly constructed steel torpedo shells, with a bursting charge of gun-cotton and a suitable fuze, and to fire the shells with the customary service initial velocities.

The experiments were very extensive and gave the following favorable results:

1. The gun-cotton shells may be fired with safety, without fear of premature explosions in the bore.
2. The shells explode at the proper moment at the object.
3. Chemical and practical experiments show that the gun-cotton employed is pure and chemically stable, so that it can be stored by itself or enclosed in the shell without danger, and finally, that the mode of charging the shell is sufficiently simple, without danger and practicable.

The system used for charging the shells was that patented by Wolff & Co. and Von Förster. The gun-cotton, as already stated, is in the form of long grains; after charging the shell the latter is filled with paraffine, in such wise as to fix the gun-cotton grains in position and fill the interstices with paraffine; the charge thus forms a compact mass, preventing thereby jamming or rubbing on the walls of the shell.

As fuze was employed the percussion fuze heretofore used with the respective shells, after having been previously made applicable to the special object here arising.

Ordinary cast-iron shells with gun-cotton and fuze were fired from:

1. The 15 cm. gun, initial velocity 400 m., reduced charge. Weight of shell, complete, 30 kg.; charge of shell 1.4 kg. gun-cotton, range 5000 m.
2. The 15 cm. rifled mortar with an initial velocity of 208 m.; shell as in 1.
3. The 21 cm. howitzer, initial velocity 250 m., weight of projectile 80 kg., charge of shell 3.7 kg., range 4000 m.
4. 24 cm. howitzer, initial velocity 231 m., range 4000 m.

24 cm. mortar, initial velocity 240 m., weight of projectile for each of the two pieces 121 kg., charge of shell 7 kg.

5. 28 cm. howitzer, initial velocity 307 m., range 6700 m.

The shell has a hardened massive point and a base fuze. Weight of projectile, 220.5 kg.; charge of shell, 7.7 kg. The steel torpedo shells were fired from the 21 cm. howitzer and the 15 cm. mortar. Charge of the 21 cm. shell, 20 kg.; range, 3500 m.

Effect of the shells in earth.—The fuzes of the shells were delayed in action, the shells were fired at high elevations and penetrated, with their high angle of fall, very deep into the earth, and therefore produced as a rule no funnel at the surface. At the firing grounds at St. Maurice the subterranean action was, however, measured by the disturbed and loosened earth, and gave as a comparison between gun-cotton and gunpowder shells the following results:

The sphere of action of gun-cotton shells in earth is somewhat greater than that of gunpowder shells. The extent of this space alone does not, however, furnish an accurate measure of the action of the two kinds of shells, but the energy developed within this space must also be considered before making any comparisons.

The gun-cotton shell triturates and pulverizes the earth in its sphere of action; the gunpowder shell simply loosens it. From this it must be concluded that a resisting object (as, for instance, a stone arch, an iron protection), which lies within the sphere of action of the explosion of gun-cotton shells, will be disturbed, while it will suffer very little from gunpowder shells.

In order, therefore, to measure the energy of the gun-cotton shell, a correspondingly definite problem must be set for it. As a matter of fact, the experiments previously made in Italy and elsewhere with this object in view also showed the great superiority of gun-cotton.

At all events, the gun-cotton shell, even though it be simply a question of the simple removal of an earth covering, which will seldom be required and will always be very tiresome, will still show its superiority, as is proven by the following numbers taken from these experiments at St. Maurice.

The extent of the spheres of action was determined from the mean of a number of shots in the following measures (the last indicating the depth):

15 cm. gun-cotton shell, 3.2 × 2.2 × 1.2 m.
15 cm. gunpowder shell, 1.8 × 1.7 × 1.9
21 cm. gun-cotton shell, 3.6 × 3.4 × 2.3
21 cm. gunpowder shell, 3.2 × 2.9 × 2.0
24 cm. gun-cotton shell, 4.7 × 4.7 × 2.0
28 cm. gun-cotton shell, 4.0 × 4.0 × 3.0
28 cm. gunpowder shell, 4.0 × 4.0 × 2.0

One of the 28 cm. shells made in addition a subterranean cavity 2 m. × 2 m. × 1.5 m.

A 24 cm. gun-cotton shell which did not penetrate as deeply into the earth as the others, made a surface funnel of 4.5 m. diameter, 1.5 m. depth.

The 21 cm. steel torpedo shells made surface funnels of 5.3 m. diameter, 1.5 m. depth, on the average.

A torpedo shell buried horizontally in earth at a depth of 1.25 m. with a charge of 20 kg., produced an explosion funnel of 5.5 m. diameter and 2.4 m. depth.

For the Italian 15 cm. and 21 cm. steel torpedo shell we also furnished gun-cotton in the form of disks, and the experiments with these too gave good results.

After the method of charging the shells in its details was decided upon and proved satisfactory, an experiment on a large scale and corresponding to reality was undertaken on the 2d of November, 1886, at Spezia, carried out to determine the action of gun-cotton shells on an experimental pontoon provided with an armored deck. Cast-iron gun-cotton shells were fired against it from the 24 cm. howitzer, and with such effect that it soon sank to its middle under water, and was only held afloat by its water-tight compartments.

On the action of gun-cotton shells, those 5 calibers in length, for instance, against fortifications, Lieutenant-General Brialmont, "La fortification du temps présent," 1885, Bruxelles, and also Snyders in the Militaire Spectator de Breda: "Schietkatoen en Schietkatoengranaten," and other authors, give results and figures, and all praise the high degree of efficiency of gun-cotton shells, adding that these shells will have the greatest effect on sieges and the construction of fortifications.

Note.—The preceding experiments have led in a large degree to the introduction of gun-cotton shells in Italy. The Dispensa XII of the year 1887 of the official Giornale d'Artiglieria e Genio contains three War Department orders, dated December 1, 1887, in which granulated gun-cotton (system of Wolff & Co. and V. Förster) is introduced for the 24 cm. mine shell, while for the 15 cm. and 21 cm. torpedo shells a charge of gun-cotton disks is selected.

II. *Firing Experiments of the Royal Italian Navy in Viareggio and Castagna in April,* 1887.—The experiments consisted in firing cast-iron shells charged with gun-cotton in the form of grains from the 228 mm. gun with 10 kg. and 17 kg. gunpowder, and from the 254 mm. gun with 18 kg. and 24 kg. gunpowder.

After it was proven by these experiments that the shells could be fired without exploding in the bore, and that they burst properly at the target, experiments were made against a target composed of compactly stamped coal, and the shells distinguished themselves by their great detonating action.

III. *Results of the firing of steel armor shells with gun-cotton and fuzes (system of Wolff & Co. and Von Förster), carried out by the Austrian Navy in the summer of* 1887, *in Pola.*—Gun: Uchatius' 15 cm. bronze gun; steel armor shell, weight complete, charged, 39.400 kg.; base fuze, gunpowder firing charge, 9.5 kg.; initial velocity, 476 m.; 300 grams gun-cotton as bursting charge.

Target 65 m. distant, consisting of armor plates of the best Steyer forged iron some 12 cm. thick, fastened between supports in the form of trestles of strong wood.

1. Firing against two such plates placed close together, one behind the other, bolted together; 6 m. in rear is a wooden target of 4 cm. thick fir boards, and behind this an earthen rampart. The shell passed through both plates, and burst behind them, the pieces piercing the wooden target and penetrating as much as ½ m. deep into the earthen rampart.

2. Firing against three such plates, placed close together, one behind another and bolted together, backings as above. The shell passed through two plates and penetrated into the third so far that its point just projected beyond it, and exploded in this position after it had expended its entire living force in penetrating the armor plate.

3. Explosion of such a 15 cm. steel armor shell, like that under Experiments 1 and 2, charged with gun-cotton, in a mine.

The shell gave the following explosion pieces:

The point remained entire	9.220 kg.
1 piece	1.700 "
1 piece	1.320 "
1 piece	1.150 "
14 pieces	between 1 kg. and 0.5 kg.
86 pieces, in toto	12.5 kg.
29 pieces	1.5 kg.

The result must be regarded as very favorable.

The point and the heavy explosion pieces preserved sufficient weight to act effectively against parts of machinery, gun-carriages in the interior of a ship or turret, etc., besides which there are innumerable pieces which will act very effectively against the men under all circumstances, and in an enclosed battery quite destructively.

Explosion and Firing Experiments

carried out in the powder works of Cramer & Buchholz, Rübeland, on the 19th of March, 1888, by Wolff & Co., Walstrode, in the presence of representatives of the Imperial German Admiralty, the Royal Prussian War Department, the Royal Italian Navy, and the Royal Italian War Department.

I.—*Firing Experiments.*

Gun.—21 cm. reinforced gun, 22 calibers long, Krupp breech-loader.

Firing Charge of Gunpowder.—Brown prismatic powder P. P. C/82 of Cramer & Buchholz, Rübeland.

Projectile.—Krupp steel shell with massive point, constructed as an armor shell, 2½ calibers long, weighing 98 kg. charged.

Bursting Charge.—1 kg. wet gun-cotton in the form of grains, covered with a coating by means of acetic ether. After the insertion of the charge, the shell is filled with paraffine so as to fill up all the interstices and fasten the charge in position. Room for the fuze is left.

Fuze.—The fuze is at the base, attached to the base screw, construction of Wolff & Co. and V. Förster. The fuze is a percussion fuze and takes up on impact a position different from its original position, in which second position only can it act on the bursting charge. (See pp. 5 and 6, and 13, 14 and 15 of the MS.) It contains an adjustable means of delaying its action.

Target.—A compound armor-plate of 12 cm. thickness, drawn from the Dilling furnace, and a wooden backing of 60 cm. oak wood in two beams. Below are 4 bolts, above 3 bolts, to fasten the plate; the bolts do not reach through the entire plate. Plate and backing are supported in front and rear by two trestles. The plate is 255 cm. broad and 170 cm. high. Behind the plate there is an explosion chamber lined with beams, the rear wall of which consists of a double layer of pine trunks 24 cm. thick and separated from the plate 5.60 m. The chamber is covered with earth externally, and the rampart in rear is 3.50 m. thick below and 1 m. at top.

Shot 1.—An uncharged steel armor shell, brought up to the weight of the charged shell, gunpowder firing charge 22 kg.; initial velocity, as near as could be determined, 420-430 m.

Result.—The shell passed smoothly through the plate, the wooden backing, the rear wall of the explosion chamber, and penetrated into the earthen rampart, where its path could be traced for 2 m., and continued into the subjacent soft ground.

Shot 2.—A complete steel shell, as previously described, charged with gun-cotton and provided with fuze; gunpowder firing charge 22 kg.

Result.—The shell passed smoothly through the plate, leaving an opening just like the uncharged shell, then through the wooden backing, the rear wall of the explosion chamber, penetrated the earthen rampart, was deflected upward in the latter and passed through it in its upper weaker part. On emerging from the rampart it exploded in the air, as was evidenced by the strong detonation, easily distinguishable from that of a charge of gunpowder.

Shot 3.—Charged steel shell, and gunpowder charge of gun as in No. 2.

Result.—The shell, like No. 2, passed through plate, backing and rear wall of explosion chamber, and exploded about 2 m. behind the latter in the rampart. In the latter there was a funnel of ⅔ m. depth and 2½ m. diameter.

Several explosion pieces flew out of the rampart; they could be heard whizzing through the air.

Shot 4.—Charged steel shell as before; gunpowder firing charge 14 kg.

Result.—The shell passed through everything in like manner as No. 3, penetrated the rampart, burst there and threw out a funnel as large as No. 3.

Subsequently, in digging in the rampart, explosion pieces were found some 2 m. behind the rear wall of the explosion chamber, weighing in all 45 kg., of which the heaviest weighed 11.5 kg. and was a part of the base of a shell. Two other smaller pieces of the base were also found, and many explosion pieces of about 1 kg. weight. Of the point nothing has been found thus far, but in better weather the search will be continued.

II.—*Explosion Experiments.*

Three shells of the same construction and charged like the previously described steel shells, but made of cast iron, were placed in a mine, and the fuze, placed in its first position, in which it could not act so as to bring the charge to detonation, was detonated by means of a Bickford fuze.

Result.—The base screw was thrown out in shells Nos. 2 and 3; the charge, according to program, did not explode, however, in any of the shells; shell No. 1 received a crack from the opening in the base through the base and side wall, a copper band broke, but the shell was not burst asunder.

In shell No. 2 a piece about ⅓ the size of the base was torn out of the base and the shell was divided into two parts along its length.

Shell 3 was torn into three large and four small pieces.

The charge in case of shell 1 was found in the shell, in 2 and 3 it lay in little clumps and separate grains partly in the shell, partly in the mine.

The effect produced was brought about only by the priming cartridge of the fuze, which, if it be incapable of breaking asunder cast-iron shells or just barely capable of accomplishing this, will probably, in case of steel shells of great resistance, be only sufficiently effective to throw out the base screw.

Such explosion experiments are often carried on with the thinner-walled shells at the gun-cotton factory at Walsrode with a similar result: never does the explosion of the fuze in its first position bring the charge of the shell to detonation.

Although it is perfectly certain that the fuze will remain in this its first position till the shell strikes the object, yet in case of an explosion of the fuze in the bore of the gun (hence prematurely), no other effect than that just described could ever follow. That is, there may be a rupture of the shell, but never a detonation of the charge of the shell. Serious damage to the gun, bursting of the chase, must be regarded as specifically out of the question.

On the other hand, it has been proven by many experiments at the gun-cotton factory at Walsrode that the fuze will bring the charge to full detonation as soon as it is brought into the second position by the impact of the shell and exploded.

The results of the experiments here described may be summed up as follows:

(1) Gun-cotton armor shells were fired without accident from the 21 cm. gun with an initial velocity of 430 m.

(2) These shells passed through the 12 cm. thick compound plate, leaving an opening of the exact size of the shell, as well as the 60 cm. thick oak backing, then the rear wall of the explosion chamber, and finally 2 m. of earth; they therefore worked their way through an armor plate and several obstructions for a distance of some 8 m., and burst only after the delay effected in the fuze was over.

(3) The charge is sufficiently great to burst the strong thick-walled 21 cm. steel armor shells and break them up into pieces sufficiently large for effective action.

(4) The fuze offers every security against any premature explosions in the bore bursting the chase of the gun or otherwise seriously injuring it.

Since, then, the explosive used, wet gun-cotton in granular form, brings with it no danger either in its handling or as regards the shock which it receives in the shell in firing, and since, moreover, our method of charging, filling out the shell charged with granulated gun-cotton with melted paraffine, is in nowise dangerous, it appears to us that, by the important and guaranteed exclusion of premature bore explosions, the possibility of introducing gun-cotton as a charge for all shells is proven. The advantages presented by the stronger charge will in very many cases make this introduction desirable.

Is it desirable, however, as is the case very generally, to regard the shell charged with a sudden explosive only as a weapon for special purposes, and to limit one's self to long steel shells with the greatest possible charge for use in mortars and howitzers: even for this purpose does our new fuze recommend itself, the principle of which, let us remark, may be applied for ignition at the head of the shell as well.

AMORPHOUS CELLULOSE.

[Translated from the *Mittheilungen aus dem Gebiete des Seewesens*, Vol. XVI, No. X, 1888, by ALBERT GLEAVES, Lieut., U. S. N.]

Amorphous cellulose is obtained from cocoanuts at the factory of Torrilhon & Co., Chamalières, near Clermont-Ferrand. It is stated that the methods of its preparation are patented for all countries, but a similar preparation has been successfully made by a firm in Italy.

Torrilhon & Co. are chiefly manufacturers of rubber goods, such as rubber tubing, etc., for railroad brakes and other supplies of like nature, rain-coats for the officers and soldiers of the French Army, and various descriptions of weather clothing.

As already stated, the cellulose is made from cocoanuts. The method of manufacture is a secret, but it is known that it is not particularly difficult, and is accomplished by purely mechanical means.

Properties of the Cellulose.—Amorphous cellulose consists of the pith or meal and the fiber. The fiber has the natural color of the cocoanut and the strength of horse-hair. The fibers vary in length from three inches to twelve inches, and when twisted together resemble human hair.

The meal, the real cellulose and the main constituent of the "kofferdams," has also the peculiar brown color of the cocoanut, consists of small granules, and is mixed with numberless little threads of the fiber. The sp. gr. of the fiber and meal, in loose conditions and not compressed, is 65 kilos. per m^3., and the sp. gr. of the compressed cellulose is 125 kilos. per m^3. The cellulose absorbs a certain amount of water, and then by its inherent property of expanding when wet it fails to take up any more. Owing to its small sp. gr., which is even less than that of cork, it makes an excellent material for life-preservers, and when used in great masses serves as a means to keep afloat a severely wounded battle-ship. Cellulose that has been thoroughly soaked can, after drying, be used with the same results as when fresh; its appearance only is changed, the color becoming lighter. When used as a floating belt for ships it is packed in the compartments .125 m. thick; it gives off no unpleasant odors, and is not liable to decay, and is said to undergo no change during two or three years' service. It is also reported that the passage of a projectile through it will not set it on fire, and in this respect it has a decided advantage over the caoutchouc belt, which, on being pierced by a shot, begins to glow and evolve a smoke so dense, unpleasant, and absolutely intolerable that it is almost impossible to get to the leak.

If dry cellulose in loose condition is ignited, it begins to smoulder and give off a whitish transparent smoke not altogether unpleasant. It leaves a black residue which greatly resembles fine soot, and which is easily pulverized between the fingers.

The burning of the cellulose is retarded by the compression of packing; it is more difficult to inflame if it is compressed when moist, and impossible to do so when wet.

A fair idea of the action of cellulose is given by the following experiment: Take an ordinary flask, fill it with water, and choke the neck with cellulose meal. Then invert the flask, and it will be found that the water will not run out at all, or only drop by drop.

Packing the Cellulose Belt of Ships.—When used as a leak-stopping material on board war-ships, the cellulose is mixed in the proportion of one part by weight of fiber and 15 parts by weight of meal. The operation of mixing is conducted as follows:

Upon a table 6½ feet square the fiber is thinly spread out in layers of .08 inch to .12 inch. The fiber forms only a network upon which to pour the meal, which is spread upon it in a layer from 1.6 inches to 2 inches in thickness and evenly distributed by hand. The entire part is then divided into strips 6 inches or 8 inches wide (6½ feet long). It is then ready for packing in the compartments.

The bottom of the compartment is entirely covered with the separate pieces; upon this layer a second, third, and eventually a fourth layer are laid. Upon this last layer a light board cover is placed, and upon the cover heavy weights or lead plates. If it is possible for a man to get into the compartment, the simplest way to pack the cellulose is by the weight of his body. The weights should be left on for a few minutes, and then fresh layers introduced and pressed in the same manner until the compartment is full. The man-hole plates are then screwed up. It is neither necessary to ventilate the compartments nor to examine them at regular intervals.

Amorphous cellulose is stowed by the Government or private firms in bales of one to five tons. Both meal and fiber are packed in sacks which bear the mark of the factory. These sacks are 65 inches high and 94.5 inches circumference; they contain 110 pounds of meal and fiber not compressed, or 176 pounds compressed. As in both cases the cellulose is pressed together, it is advisable, before using it, to empty it out of the sacks and let it resume its natural thickness.

Price.—1 kilo. of meal at the factory costs 1.75 francs. The cost of packing and transportation to the railroad station near Chamalières is 10 to 15 centimes per sack. The weight of the sack is included with the cellulose.

Cellulose in the French Navy.—The French service was the first to adopt cellulose in the construction of their men-of-war, and Russia and Japan have followed the example. Large quantities of the material have already been used. In 1883 the orders from the French Navy amounted to 10,000 kg.; in 1884, 190,000 kg.; in 1885, 40,000 kg.; in 1886, 165,000 kg.; and in 1887, 74,000 kg. Since 1886, 165,000 tons (long) have been used. The Amiral Cecille, 5766 tons, carries 40,000 kg.; the Tage, 73,000 kg.; and the Surcouf, 26,000 kg. According to a statement of the factory officials, the Frency Navy has ordered and actually used 700,000 kg., Russia 80,000 kg., and Japan 225,000 kg. It is also reported that the Italians, Spanish, Greeks, and Danes are using cellulose in the construction of their ships now building.

Inspection.—The test of the cellulose for the navy consists of its inspection with regard to color, specific gravity, and particularly its capacity for absorbing water. Concerning the last, the test is conducted in this way: A chest-shaped receiver about 8 or 10 inches long is filled with cellulose. In the top of the chest is a hole 2 inches in diameter, covered by a fine machine-made sieve of twisted brass wire. The chest is suspended from a scale and submerged in water to a depth of 10 feet, and left there until it is known how much water is taken up in a certain time. The specification requires that not more than 13 pounds shall be absorbed in 10 hours, or 22 pounds in 18 hours. The increase in weight is read off directly from the scale.

Firing Trial.—At Toulon a 27-cm. projectile was fired through a belt of cellulose. Only 14 or 15 liters flowed through the shot-hole, and most of this came through immediately after the shot; after a little while the flow ceased entirely.

The Factory Test.—To demonstrate the quickness with which cellulose acts in stopping a leak, the following experiment was made at the factory:

A wooden cask divided into two parts by a thin white tin partition, is filled with cellulose to the required thickness of .125 m. The cask is intended to represent a portion of the ship's belt, and is placed in a second and larger cask, the space between the two serving as a water-chamber. The joints were all screwed firmly together and made perfectly water-tight. A rubber funnel with a stop-cock is fitted on top of the chamber and connected with a reservoir by a rubber pipe 2.8 inches in diameter. When the cock is opened the water-chamber is in direct communication with the reservoir, which being 5 feet above the cellulose, an adequate water-pressure is easily obtained.

The object was to prove the small quantity of water that would be admitted into a ship by the penetration of the belt by a 15-cm. projectile. The flight of the shot was imitated in the following manner:

A wooden model of a 15-cm. shell was secured on an iron rod .8 inch in diameter. The rod was shoved through the cellulose, and the wooden shot adjusted on the rod at a distance of 7.87 inches from the box containing it. A chain fitted with a slip-hook was shackled to one end of the rod, and at the other end of the rod was fastened another chain which led over a pulley and made fast to a weight of 3740 pounds. When the slip-hook was let go, the weight dropped 16½ feet, drawing the rod, together with the wooden shot, through the cellulose. Five or six liters of water entered the cellulose at once, but the flow rapidly decreased, and in a quarter of an hour only one to one and a half liters per minute came in. This remained constant for two hours. The opening in the side of the box was then plugged with cellulose, and no more water entered.

The value of amorphous cellulose as a leak-stopping material thus seems to be demonstrated, and its small sp. gr. and cheapness are further advantages in its favor.

In conclusion it may be added that cellulose has been found to be a good excitant in an electric cell. In the factory at Chamalières elements of this kind are prepared. In a small cell containing the copper and zinc plates is placed cellulose, over which is poured dilute sulphuric acid. A battery of this kind is said to have run a year and given very little trouble.

GRAYDON TORPEDO THROWER.

Under the above heading we have drawings and descriptions of a number of Mr. Graydon's alleged inventions.

In the description of these inventions the following gives us the keynote of his plan: "The only pneumatic gun for military and naval purposes, designed to throw torpedoes of dynamite or other high explosives, heretofore brought to the attention of the Government, is that known as the 'Zalinski gun.' Its operations have been attended with varying degrees of success, but its promoters have by no means solved the problem." With this as a text he expands his system. Knowing that it would be an advantage to shorten the gun, he makes his gun one-half the length of the Zalinski gun and greatly increases the air pressure. He claims to be able to do this with perfect safety, "owing to the peculiar system of handling the high explosives and charging the torpedoes so as to render premature explosion in the impulse tube or elsewhere *impossible from any cause*." There can be no doubt that Captain Zalinski has thoroughly understood the advantages of short guns and high pressure, and has only adopted the length and pressure of his system after many experiments. We know his system to be safe. Mr. Graydon claims much, but has no results to back his claim. If his peculiar system of the high explosives and charging the torpedoes renders premature explosion *impossible from any cause*, why does he adopt air pressures limited by the power of the air compressors? Why not adopt gunpowder and throw his projectile from a modern high-power gun? He claims an extreme range of three miles and may be able to attain it, still it is doubtful if this is any great gain over the Zalinski gun for naval purposes. The latter has a range of about one mile, and the opening range for the present powder guns fired from ships against ships is laid down at 2000 yards, as at this point the target will probably catch one-fourth of the shots fired. It is not probable that the aerial torpedo thrower, supplied with comparatively few projectiles, can open at a longer range with advantage. Many objections are urged against the Zalinski electric fuze, and Mr. Graydon claims to have a perfect electric fuze. Captain Zalinski's fuze has proved a success in numerous trials, Mr. Graydon's may do the same. Another point: "The rigid tail-piece employed in the Zalinski projectiles is an ungainly and cumbersome affair. The Graydon torpedo has a flexible telescopic kite-tail attachment which takes up no storage room, so necessary to economize in all cases; while it performs the part of guide and balance." If the telescopic kite-tail will serve as a guide and balance it will be a gain over the rigid tail-piece, but knowing the difficulty experienced in the trials with the Zalinski projectile, owing to the insecure fastening of some of the vanes, it is doubtful whether the flexible telescopic tail will stand the test, particularly when higher velocities are attempted. There are several other drawings and descriptions of revolving torpedo throwers, dynamite canister, shrapnel and grape that may or may not prove useful if ever brought to the test of a trial.

The fact is, Mr. Graydon has taken the Zalinski system and noticed points where he thinks it would be an advantage if the system could be improved, and has then very ingeniously worked out these improvements on paper. The Zalinski gun has been tested and has received favorable reports: we have yet to hear of any trial of the Graydon torpedo thrower. Certainly it is difficult to believe that the military and naval officers of the United States are as credulous as this pamphlet states: "Three-fourths of the military and naval officers of the United States and of foreign powers approve the two chief inventions of Lieutenant Graydon, viz., the aerial torpedo thrower herein described, and also his system of firing high explosives from powder guns, as artillery practice proper." R. W.

INDORSEMENT OF THE HONORABLE SECRETARY OF THE NAVY ON THE REPORT OF BOARD ON TRIAL OF DYNAMITE GUN.*

Navy Department, Washington, *February* 21, 1889.

The tests for accuracy of the pneumatic dynamite gun, the result of which is recorded in the within report, are satisfactory to the Department, and notice may be given to the company to that effect. The substance of the report is that, taking as a target a space upon the surface of the water 50 by 150 feet (which is considerably less than would be occupied by an ordinary vessel of war), and marking out by buoys one such target at 360 yards, another at 1700 yards, and a third at 2100 yards from the muzzle of the gun, the points being selected by range shots, the pneumatic power worked with such accuracy that more than one-half of the projectiles fired at the respective ranges fell within the target in each case. These results are more than satisfactory. The effective range of the guns is also shown to be largely in excess of the requirements of the statute and contract. The law provided for dynamite guns "of a 10½-inch caliber, and guaranteed to throw shells containing 200 pounds of dynamite or other high explosive at least one mile." The company constructed the guns of 15-inch caliber instead of 10½ without additional expense to the Government, and this report records the fact that—

*Army and Navy Register, March 2, 1889.

The twenty-second shot is notable as showing the range of the 15-inch projectile carrying 500 pounds of high explosive to be practically beyond a mile, as the loss of a few more pounds of pressure would certainly have carried it over the 16 yards by which it fell short of that distance.

In another portion of the report, referring to the explosion of a projectile containing 500 pounds of dynamite, it says:

The crater formed by the explosion of this shell was, as may be seen from the photograph, something unusually fine even in the eyes of those accustomed to torpedo explosions. In this connection it may be well to note that no such mass of explosive has ever before been fired from a gun of any description.

A 220-pound projectile was thrown a distance of about 1¾ miles. Minor defects in the working of the mechanism of a new weapon, such as this is, are to be expected until by practice and experiment details shall in all respects have been perfected. The general results of these experiments must be deemed to mark a notable event in the progress of the arts with which this Department is concerned.

Very respectfully,
W. C. WHITNEY,
Secretary of the Navy.

NAVAL GEOGRAPHY.

It is the purpose of this article to suggest the collation of certain classes of facts possessing a naval bearing, hitherto treated of irregularly, separately, or else altogether overlooked, into a separate branch of study, and to advocate the incorporation of the same into the elementary naval curriculum, as a sub-branch of some existing department thereof. These facts, important in geographical, commercial and military senses, would, when arranged in accordance with a certain scheme, constitute the data for the study of Naval Geography.

Our geographies are faulty. They give but little evidence of any systematic effort towards the classification, in accordance with any scheme of relative importance, of the various towns and seaports set down upon their maps. Centers of activity, agricultural, mining and commercial, are often barely noted—sometimes altogether overlooked—while places that in the past may have played some momentarily significant rôle are yet presented in their original magnitude. How many of them make any particular mention of Chemul-p'ho, now the chief outlet of Korea, whose development is rapidly leading to the shifting of a national trade from a caravan route to China to an open road abroad by sea? How many point out that as many tons of merchandise now pass yearly through the Sault Sainte Marie as through the Suez Canal?

Again, geographical study should have to the naval student a peculiar signification and bearing. Others view the sea from the land; he is to view the land from the sea. Being attached to the executive branch of the Government, the changes of the present are of more importance to him than the distributions of the past. It is with the aim of increasing his knowledge of the element upon which he is to serve, and of bringing up to date the knowledge that he may already possess, that the following classification of subjects, to be treated under the heading above given, is made.

1. *The Geography of the Seas.*—A general description of the oceans, of their deep and shallow areas, their islands and archipelagoes, the natural position, character and structure of their dangers. A simple arrangement and classification of the great and well-defined currents, and the winds that are subject to known laws of variation, with their prevailing directions at certain seasons of the year. The close study of the cyclone, however, is not here intended, as it involves the question of the handling of the ship, and could therefore be more properly discussed under the heading of Seamanship. A sketch of the ocean coast-lines, with the distribution of harbors as to character and frequency; also,

a description of the tidal movement along them, and a mention of those shore-lines and areas that are as yet unsurveyed, or but partially surveyed.

2. *The Principal Steam and Sail Commercial Routes.*—In direct ratio with the development of the ship and the advance in meteorological knowledge, the certainty of navigation and the definiteness of the sea-route have been increased. It has become possible to create ocean lanes for purposes of safety; a regular variation in path, in accordance with the seasons of the year, may be observed for vessels navigating the waters of the temperate zone, while in tropical waters the routes taken by successive steamers from port to port are in many cases nearly identical at all times.

The more certain knowledge of the winds of the globe has also led to increased regularity in the movement of sailing craft, and has brought about not only a reduction of traversed area, but also an actual shortening of time of passage. Of this the work of Maury, who, from the comparative study of data obtained from the logs of a large number of sailing vessels running from New York to the equator, succeeded in mapping out a route by the following of which the average time of passage could be reduced ten days, is a brilliant example.

3. *The Great Trades of the World.*—The transfer of staple commodities across the ocean is in accordance with general laws governing time of shipment, production, and direction of movement. The student should know something of our own foreign commerce, of its nature and distribution, and of those of our own products upon which other countries are more or less dependent for support.

4. *Naval Ports, Colonies, and Coaling Stations.*—The chief commercial ports and naval stations of the world are centers of financial, engineering and military enterprise, and as such are of especial interest to the naval student. Short descriptions of these, with notes as to size, character and extent of harbor, should be given. Special attention should be paid to those of our own country.

The colonial possessions of other countries; their relations, political and commercial, with the mother country. The position and importance of coaling stations. It may be well to add that under this head no more than a brief statement of facts would be made, the discussion of strategic questions belonging elsewhere, and for minds more mature than those for whom this elementary collection of data would be intended.

5. *Communications.*—A brief description and enumeration of the chief trans-oceanic steamer lines, especially those that carry the mails, and those that are under government subsidy, giving their itineraries. Notes on the world's network of telegraphic cables, on the general character of cable landings, and on proposed extensions of the system.

6. *Meteorology.*—The advances that have recently been made in meteorological science. The system of simultaneous international meteorological observations. Maury's weather charts. The "square" system. Recent U. S. naval meteorological work. The North Atlantic pilot chart. Systems of coast signal stations and weather forecasts. Meteorological instruments in practical use afloat. Employment of the same. Errors to be avoided in observation.

The above is a brief résumé of the subjects to be included under the head of Naval Geography. Should the study ever be developed, it is very probable that its scope would be modified, and the matter herein not dwelt upon would be taken up.

Any departure from existing methods becomes doubly worthy of consideration when it has met with the approval of those in authority. It happens that in this case not only has approval been given, but that a step towards the establishment of such a course has, in one country at least, been made. Among the programmes of subjects studied at the Russian Naval School in 1887–8 was one entitled "Statistics and Geography of the Seas," of which I here give a rough translation.

STATISTICS AND GEOGRAPHY OF THE SEAS.

Definition of statistics. Development of statistics. Relation of statistics to geography and history. Statistical fact. Methods of representing statistical facts, arithmetical and graphical. Statistical institutions, temporary and permanent. Definition of empire. End of empire.

Territory.—Importance of territorial relation. Meaning of the development of boundary. Relation of boundary to area in Russia and in other first-class European empires. Peculiarities of movement of trade for ports of the Baltic, Black, Azov and White Seas. Peculiarities and particulars of the water boundaries of Russia. Statistical review of Russia, orographic and hydrographic. Influence of extent on the welfare of the Empire. Influence of the extent of Russia on its political and economical relations. Influence of soil and climate on the welfare of its inhabitants. Soil of Russia; climate of Russia; distribution of atmospheric precipitation.

Population.—Theory of Malthus. Movement of population; classification of population by sex and age; births, deaths, causes influencing death, natural causes; climate and soil in relation to age; disease; means of existence; kinds of occupations; acclimatization; enumeration of population.

Popular Activity.—Conceptions of needs, utilities and values. Labor and its rôle. Capital and its rôle. Savings banks; insurance companies. Union of capital (shares, obligations, dividends). Agricultural system in Russia, and special features thereof. Products of Russia: breadstuffs, beet-root, potatoes. Horticultural gardening, forestry, raising of cattle.

Geography of the Seas.—Great or Pacific Ocean. Position, size, importance in the world's trade. Time required to cross. Sea, gulfs and straits. Change of name on coast of Asia, America. Inhabitants. Foreign and native populations. Notes on docks, dock-yards, trade centers, coal deposits and other belongings. Telegraphs and commerce. Ocean cables.

Such is the scope of one branch of Russian naval education, one to which we can offer in our system no parallel. In some respects there is none needed, the generalities of the Malthusian doctrine, and the relations, social and political, of the members of an empire to one another, being of no importance to us. In others this programme would seem well worthy of attention, as it bears witness to an effort to place before the student matter of professional importance which is of a nature closely in keeping with the progress of the day, and which is not treated of in any other department of professional study.

Should it be deemed advisable at any future time to develop this subject, an elementary text-book could easily be compiled from the sources of information now available to the Office of Naval Intelligence.

J. B. BERNADOU, *Ensign, U. S. Navy.*

KRUPP'S TRIALS OF A NEW POWDER.

[*Deutsche Heeres-Zeitung*, February 9, 1889.]

Krupp's last report, No. 73, October, 1888, gives a very important account of experiments with a new powder manufactured by the "United Rheinisch-Westphalian Powder Co." According to the report, the brown prismatic of this company has been as successful as that of the Rottweil-Hamburg Factory, without an important increase of pressure.

After long trials the United Rheinisch-Westphalian Company has succeeded in introducing a new powder, which not only does more work than the earlier powders, with less pressure, but which also possesses the property of evolving much less smoke, a result which has been desired for a long time.

Krupp has at last given to the public the result of the trials with this powder, and the information merits the closest attention of the military world.

There are two grades of the new powder, namely: 1, Rough granulated gunpowder C/86, for use in the small calibers (4 cm. to 8.7 cm.), and 2d, prismatic powder C/86, at present used and treated in the medium calibers (10.5 cm. to 25 cm.).

The first kind, the rough granulated powder, corresponds pretty closely in form, coarseness of granulation and color with field cannon powder in use until recently, but differs in composition. The advantages claimed are, 1st, greater efficiency per kilogram; 2d, easier recoil; 3d, less and thinner smoke, disappearing more rapidly, thereby interfering less with sighting; and 4th, less flame.

On the other hand, the new powder has the disadvantage of being much more hygroscopic than the old. But, since it is necessary to pack even the old powder in air-tight cases to preserve its efficiency during long stowage, this objection is not so great as it would be if the powder were stowed in kegs. In order to preserve this powder in cartridges during transportation in the field, metallic cases, such as were used during the experiments, will probably have to be used.

The trials of the powder showed, 1st, the increase of efficiency per kilo. as compared with the old; 2d, the proportion of the increase of efficiency; and 3d, the loss of efficiency due to long stowage.

The following table shows a summary of the experiments:

Gun Caliber. Inches.	Powder.		Projectile. Pounds.	Initial Velocity. f. s.	Pressure. Tons per sq. in.
	Nature.	Weight Charge. Ounces.			
1.575	G. G. P. C/86 (new).	12.35	1.76	2145	13.7
"	R. 8.85 (old).	12.35	"	1860	12
"	G. G. P. 6–10 cm. H. 85 (old).	14.11	"	1975	14.2
"	G. G. P. C/86 (new).	10.58	"	1961	11.4
1.968	" "	21.64	3.85	1991	13.6
"	" "	22.93	"	2054	13.95
"	R. 8.85 (old).	29.98	"	1985	16
"	G. G. P. 6–10 cm. H. 85 (old).	21.64	"	1597	9.7
2.362	G. G. P. C/86 (new).	35.27	6.6	2011	13.4
"	R. 8.85 (old).	47.62	"	1902	14.2
"	G. G. P. 6–10 cm. H. 86 (old).	35.27	"	1620	11.8
2.953 (30 cals.)	G. G. P. C/86 (new).	42.33	8.36	1512	11.15
"	R. 8.85 (old).	52.91	"	1486	13.7
2.953 (40 cals.)	G. G. P. C/86 (new).	70.55	"	1928	13.95
"	10–13 cm. H. 80 (old).	70.55	"	1519	12.1
3.307	G. G. P. C/86 (new).	49.38	15.4	1746	14.2
"	R. 8.85 (old).	63.49	"	1657	15.4
3.426	G. G. P. C/86 (new).	38.80	18	1368	..
"	6–10 cm. Hg. 84 (old).	52.91	"	1401	..

From these results it follows that the new powder G. G. P. C/86 is about 1¼ or 1⅓ times more efficient than the old, and that for the same velocities only ¾ of the amount used in the old charge is required.

The following table exhibits the evenness of performance of the new powder:

Date.	Gun.	Weight of Powder. Ounces.	Weight of Projectile. Pounds.	No. of Rounds.	Average I. V.	Difference.	Remarks.
24 May, '87	7.5 cm.	47.62	19.41	5	1633	+ 6½' and — 23'	Service cartridges
" "	"	47.62	19.41	5	1633	± 10'	
8 Jan. '88	"	47.62	19.41	10	1637	+ 10' and — 6½'	
27 July, '87	7.5 cm.	42.33	23.99	11	1594	+ 16' and — 13'	Metallic cartridge cases.
2 Mar. '88	"	42.33	23.99	5	1591	+ 7' and — 3'	
22 July, '88	8.4 cm.	49.38	24.69	10	1699	+ 16' and — 13'	
27 July, '88	"	49.38	24.69	10	1706	+ 13'	

As the powder has already been stowed two years in the magazine, an opinion may be formed from the experiment of its keeping qualities.

We give here only some of the results lying farthest apart, and therefore showing proportionately the greatest differences.

Date.	Gun.	Powder (new).	Charge.	Projectile.	Initial velocity	Pressure. Tons.
March, 1887	7.5 cm.	H. 8.86, No. 132	44.1 ozs.	24 ozs.	1627	13.15
March, 1888	"	" "	"	"	1614	13.25
June, 1886	"	H. 5.86, 113 I/III	47.6 ozs.	"	1647	13.15
March, 1888	"	" "	"	"	1623	13.1

These firings, besides others given in the report, show that the new powder does not lose more in velocity than the old rough granulated powder.

The new prismatic powder of 10–15 cm. $\left(\frac{\text{P. P. C/86}}{\text{10–15 cm.}}\right)$ was tested in the 10.5 cm. of 35 cals., 15-cm. gun of 25 cals., and the 15-cm. siege guns of 28 and 30 cals., and gave results equal to the old prismatic powder, $\frac{\text{P. P. C. 82}}{\text{10–15 cm.}}$.

It is sufficient to quote here some of the results obtained from the two powders in these guns.

Gun.	Powder.		Projectile.	Initial Velocity.	Pressure.
	Nature.	Charge.			
10.5 cm.	New.	8.6 lbs.	39.7 lbs.	1729	12.9
"	Old C. 82.	10.4	39.7	1637	13.7
15 cm. (siege) 28 cals.	New.	18.7	86	1736	14.1
" "	Old C. 82.	33.1	86	1736	15.7
15 cm. (siege) 30 cals.	New.	17.6	86	1660	11.3
" "	Old C. 82.	22.1	86	1670	13.4
15 cm. (naval) 35 cals.	C. 86, 15–20 cm.	34.2	110	1945	15.4
" "	C. 82 (old).	51.8	110	1942	16.7

The above tables, and almost all the rest of the data contained in the report, show, 1st. That the efficiency of the new prismatic C/86 is really greater per kilo. than the old C.82. 2d. That the powder C.86 gives the same initial velocity with less pressure than the old C.82. 3d. That with C/86 a velocity can be obtained without exceeding the allowable pressure that C/82 cannot give.

While the United Rheinisch-Westphalian Company are to be congratulated on their success, the country is scarcely in a condition to profit by their rapid advances in powder-making, as the magazines are at present filled with the old powder. A. G.

THE GUN OF THE AMIRAL DUPERRÉ.

[Translated from the *Deutsche Heeres-Zeitung*.]

The terrible accident on board the Amiral Duperré is still fresh in the public mind. On the 12th of last December the 34-cm. (13.4-inch) gun in the after-turret of this ship was burst by the ordinary service charge of powder. The breech of the gun was blown overboard after it had penetrated the shield which protects the crew from shots from the rapid-fire and revolving guns. An officer, sub-officer, the chief mate, and three seamen gunners were killed.

As this is the first serious accident to our ordnance since the introduction of steel guns in the fleet, all possible theories have been advanced to explain the cause. Instead of giving ourselves up to such speculations, it seems wiser to await the official reports, which will not be published until a thorough examination has been made of the gun and powder. A brief description of the gun, however, will be appropriate.

The gun is of the model of 1875, and was one of the first of the new steel construction introduced in the French Navy. It was entirely of steel, strengthened on the outside by hoops, and on the inside by a tube extending as far as the screw-box. The charge was 258 pounds W. 30/38 powder, the projectile weighed 726 pounds, and was a steel shell. The initial velocity was 1595 f. s. It will be well to remember these figures.

The ordnance of 1875 was antagonized by many of the best naval artillery officers, and was bitterly opposed by the distinguished and lamented General Frébault. The Ruelle Foundry at this time guaranteed every security for cast-iron, but steel, on account of its lesser weight and other good qualities, had warm advocates in naval councils, and finally won the victory. Cast-iron was banished from the coast defense, and steel was exclusively used for naval guns. The model of 1875, however, was not perfect, and artillerists and metallurgists set to work, the former to improve the methods of gun construction, the latter to improve the metal, and with such success that the guns and the steel of to-day are vastly superior to the model of 1875. Besides, trials on the proving ground at Gavres had shown the advantage of a few changes in the old model, and of strengthening the gun by the introduction of a tube the entire length. The changes were adopted for the guns then in course of construction, but as, since the arming of the fleet with these guns, no accident had happened, it was not deemed necessary to strengthen the guns already afloat. Time passed, and a new factor entered into the question; the rough granulated powder which had been used in former years was displaced by the brown prismatic powder of hexagonal prisms. This powder, commonly known as cocoa powder, burnt slower, strained the gun less than the granulated powder, and imparted a higher initial velocity to the projectile. After long trials it was introduced in the service. The gases evolved from this powder produced an immense pressure in the chamber and bore of the gun, but it had been proved by experiment that a heavy, well-constructed gun easily endures a chamber pressure of 16 tons to the square inch. Considering this fact, and after a number of firings, it was concluded that a charge of 304 pounds of brown powder, P. B. S., did not strain the 34-cm. gun as much as 258 pounds of W. 30/38. With the former charge an initial velocity of 1823.6 f. s. was obtained instead of 1595 f. s., and consequently the gun had greater range and deeper penetration. As is well known, it was the use of this charge of 304 pounds that burst the gun.

It will be seen from what has been said that the accident is attributable to one of three causes : the metal, the construction, or the powder. Previous trials at Toulon have demonstrated that the metal was perfectly sound; although infinitely better steel is produced to-day, this showed neither flaws nor blisters. Concerning the construction, a careful examination of the other guns of this model have shown them to be in excellent condition. But as recent guns are far superior to those built in 1875, and such great progress has been made in construction by the employment of separate parts, no one can affirm that the model of 1875 was free from danger.

The question of powder remains to be considered. Brown powder has been in use a comparatively short time, and although it was tested before issue with the greatest care and caution, that on board the Amiral Duperré was found to be in an especially peculiar condition. The temperature in the magazines where the powder was stowed was found to rise at times as high as 127° F. The powder thus exposed to an abnormal drying process would naturally burn quicker than any one could foresee, and the great pressure it developed when fired was sufficient to burst the gun.

In order to avoid accidents in future, it is only necessary to reduce the charge, and this has been done already. Admiral Krantz has ordered that hereafter the charge shall be calculated with reference, not to the pressure, but to the initial velocity of 1595 f. s., which had been fixed originally for the 34-cm. gun of the model 1875. In this way the advantages of brown powder will be obtained by relieving the strains in the bore rather than by improving the ballistic qualities of the gun. It has also been ordered that the magazines of ships shall be better isolated, in order to avoid the excessive rise of temperature which was observed on board the Amiral Duperré.

Conclusions.—It can be assumed that the catastrophe which we have to deplore was purely accidental, and that the quality of the steel should not be questioned, as the metal does not appear to have been in fault. Finally, we maintain that it is good to repeat our assertion that the later models are immeasurably superior to the original construction ; that since 1875 great advances have been made in the fabrication of guns ; and that all accidents can be avoided by not straining the gun to its utmost limits of endurance.

We have just passed through a period which favored the dangerous maxim to "claim for every war-engine the highest efficiency." As a consequence of this erroneous demand, accidents without number have occurred in France and other countries to ships and engines of light build. A reaction has justly set in against this system, the dangers of which we have from time to time pointed out, and it is to be hoped, in the interest of our finance and naval material, that we will not have a repetition of a doctrine which has been attended by such disastrous results. A. G.

SEAMLESS TUBES FOR GUN-MAKING.

Another advocate of mild steel, William Henry Browne, has brought forward a method of building up modern high-power guns. This is done under his patents for drawing seamless tubes from boiler plates. "A circular piece of mild steel boiler plate is rolled until it is certain there are no cavities in it (?).

The plate is one-half inch in thickness, and is pushed through dies by means of hydraulic pressure. This dishes up the sides of the plate until it resembles a saucer. The process is repeated until a tube of the required diameter and about one and one-eighth inches in thickness is formed. The sides are absolutely uniform in thickness. The bottom is then cut off, and similar shells or tubes of larger diameter are formed about the core. These form the barrel of the gun, and the shells are so closely united that layers cannot be detected when the ends are turned in a lathe. Shorter tubes are added to reinforce the butt of the gun."*

He claims that the finished tubes have stood the test of 100,000 pounds to the square inch when made of plate of 60,000 pounds tensile strength. He says: "The shells are necessarily true inside and out, and by being passed through the dies cold a few times become hardened. This is where the tensile strength is increased."

It seems as if 100,000 pounds tensile were rather high for mild steel, and that drawing cold might cause a cold flow of metal that would leave injurious strains and stresses. This is but another form of a built-up gun, using milder steel than that ordinarily used. By a greater amount of work he may be able to produce the same tensile strength as in the ordnance steel, without destroying the elongation, etc., and his process may have the advantage of being cheaper. The trouble generally with the advocates of new methods of gun-making is that they assume they can produce the same effects with large masses as with small, and in this they almost invariably fail. There is one great advantage of this method over that of casting. You should be able to tell from the tubes the class of gun you were getting, and not be troubled with hidden defects, as in casting. Again, if one good gun was produced, there should be no difficulty in producing any number; whereas, even if one good cast-steel gun could be produced, there would be no certainty that the man who made the cast might not fail in making others, and a great uncertainty as to whether others could cast successfully by the same method. The advocates of cast-steel guns expect to produce the effects of work in the metal without the trouble and expense of working it, and by using masses of metal of low tensile strength to make a gun that will stand high strains. This they will do when the perpetual motion machine is invented. The method of gun-making under consideration has the advantage of proposing to work the metal, the question being if it can be done cheaply and produce the effects as claimed. R. W.

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* The *Evening Journal*, Jersey City, N. J.

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ANNALEN D. HYDROGRAPHIE U. MARITIMEN METEOROLOGIE.

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February 23. Measured mile speeds (editorial).

March 23. Notes on the treatment of tool steel.

April 6. Squatting of screw steamers.

April 20. Squatting of screw steamers (No. 2). Sea-going torpedo-boats. Artificial cold without machinery.

May 18. Stuffing-box for propeller shaft. F. H. E.

DEUTSCHE HEERES-ZEITUNG.

January 16. The German marine and what is more needed than money. A plea in favor of a more homogeneous engineer corps. A military carrier-pigeon race at Kiew, Russia. Review of the British navy up to January, 1888. Description of the Howell torpedo.

January 19. Description of a new electric apparatus, indicating, by means of a floating cylinder filled with mercury and connected with an electric battery, when the vessel is in shoal water. List of the dead and wounded during the fight at Samoa.

January 23. Description of the large electric lighthouse on the Isle of Wight. Biographical sketch of Count v. Monts, late Admiral of the German navy. Notes on the Nordenfelt electric torpedo.

January 26. Account of the engagement between the German gunboat Meteor and the French despatch-boat Bouvet in 1870 (related in connection with the promotion of Rear-Admiral Knorr, former commander of the Meteor). Discussion at the German Reichstag of the naval estimates for 1889. Proposed stations of the vessels of the Italian navy for 1889–90. The bursting of the gun of the Amiral-Duperré (translated from *Le Temps*).

FEBRUARY, 1889, NO. 10. Proposed increase of 5700 men to the corps of enlisted seamen of the Italian navy; total force for 1889–90, 20,300 men. The German fleet of ironclads as compared with the fleets of ironclads of England, France, Italy, and Russia.

NOS. 11, 12. Drill regulations for field artillery. Report LXXIII of target practice with Krupp guns, containing important information of trials with a new powder from the Rheinisch-Westphälischen powder mills.

The advantages of this new prismatic powder, as claimed, are, besides producing very little smoke, fire, and an easy recoil: 1st. Greater effective power per kilo as compared with the old powder; 2d, same velocity with less pressure as compared with the old powder; 3d, possibility of obtaining greater velocity without exceeding the standard pressure as compared with the old powder.

Complete list of the killed and wounded German officers and men during the fight at Apia, Samoa, December 18, 1888.

14 killed and 40 wounded, 3 of whom have since died.

NO. 13. New target regulations for the Italian infantry. The new English drill-book. Account of the French naval manœuvres at Toulon.

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MARCH 2. On the history of the German navy. Order by Emperor William congratulating the officers and men of the vessels Olga, Adler, and Eber on their bravery in the engagement at Samoa. Detail of relief crews for different vessels of the German navy stationed at distant ports. Imperial order on the disposal of the prizes taken during the blockade of the east African coast.

MARCH 9. Detail of crew for the Imperial yacht Hohenzollern. Proposed increase of the English navy.

MARCH 13. New regulations for the enlistment of naval apprentices in the Italian navy.

MARCH 16. English navy ship-building programme.

MARCH 20. The increase of the English navy (70 new vessels, to cost 21½ million pounds sterling). Organization of a new battalion of marine infantry of the I. German navy. New cadets and officers for the Italian navy. Stranding of H. M. S. Sultan.

MARCH 27. Imperial order on the organization of a new battalion of marine infantry. Marine school of telegraphy.

MARCH 30. Modifications in the German marine budget. Sinking of a French torpedo-boat. Unsatisfactory trials with the electric submarine boat Peral at Cadiz, Spain.

April, No. 27. Official report of the loss of the German vessels at Apia.

No. 28. New regulations for salutes and signaling with flags. Imperial proclamation on the loss of the officers and men of the German vessels Adler and Eber. New regulations for admission to the Italian naval academy at Livorno for 1889–90. England: Programme of the fleet for 1889. Launching of new gun and torpedo-boats. Recruiting of marines. Russia: Naval estimates for 1889.

No. 29. Information on the movement of German vessels.

No. 30. Coast artillery in Italy; tests of new guns for coast defense.

No. 31. Italy: Trial trips between Genoa and Spezia of six new torpedo-boats. Grading the course of students at the Italian naval academy. England: Condemnation of 30 English war-vessels of obsolete type.

Nos. 32, 33. England: Health report of the English fleet for 1887. The completion of the new gunboat Pigmy at Sheerness, and launch of the torpedo-cruiser Spanker. The new cruiser Pallas, to be built at Portsmouth for the Australian government, and launch of the screw despatch-boat Beagle. Brazil: The association of naval officers of Brazil is publishing, since October, 1888, an excellent monthly periodical under the title of *Boletim do Club Naval*, its object being the promotion of professional studies in the Brazilian navy. H. M.

INSTITUTION OF MECHANICAL ENGINEERS (LONDON), PROCEEDINGS.

October, 1888. Description of Emery's testing machine (adjourned discussion). Description of the compound steam turbine and turbo-electric generator (plates).

Advantages.—The characteristic advantages of the turbo-electric generators may be summed up as follows: Steadiness of the electric current produced, arising from the high speed and the momentum stored in the moving parts; freedom from accident on account of simplicity and direct action; small first cost, and small cost of maintenance of machine and lamps; small consumption of oil; little attention required; small size and weight for the power developed, which is about nine watts per pound of weight in the whole machine, including both engine and dynamo; consequently they are specially suitable for torpedo-boats and fast cruisers where weight and space are of the utmost importance.

Report upon experiments on double-riveted lap and butt joints, made with thicker plates and larger rivets closed under heavier pressures (plates). F. H. E.

THE JOURNAL OF THE AMERICAN SOCIETY OF NAVAL ENGINEERS.

The Journal of the Association of Naval Engineers has met with well merited favor by the officers of the Navy. This organized effort of the officers of the

Engineer Corps to advance professional research, and place upon record valuable results of the experience and study of naval engineers and others interested in that profession, is a natural outgrowth of the spirit that is accompanying the rehabilitation of our Navy. The Institute extends a warm welcome to its sister society, and wishes it a prosperous and useful career.

FEBRUARY, 1889. Progressive trials of the steam barge of the commandant of the New York navy-yard. Duty and capacity tests of the high-service pumping engines, Washington, D. C. Some problems in propulsion. Notes on coals of the Pacific coast. Increase of horse-power for a given speed due to foul condition of ship's bottom. Notes on quadruple-expansion engines.

MAY, 1889. Phenomena attending ship propulsion. Coals of Alabama. Screw propeller action. Inspection and tests of steel plates. Forced draft trial of U. S. S. Yorktown. Formula for diameter of cylinders for successive expansion engines. Development of the marine engine (translation). Detecting adulterations in olive oil. Recent merchant steamers. F. H. E.

MITTHEILUNGEN AUS DEM GEBIETE DES SEEWESENS.

VOLUME XVI, NO. 12, 1888. Procedure in designing ships' engines. Contribution to the question as to the advisability of appointing naval officers consuls in ports. Memorial on the budget for the administration of the Imperial German Navy for the fiscal year 1889-90. Right of way at sea; how has a merchant vessel to behave when meeting a manœuvring fleet? Roumanian coast-guard vessels. Firing trials against French and Italian armor plates. English engineer pupils. The Italian armor-clad Re Umberto. Torpedo-boats for Russia. Torpedo-boats and vessels with triple-expansion engines which have been built and are in course of construction by F. Schichau in Elbing. Submarine boats. Flash powder for use in the illumination of coasts. Literary reviews: Influence of the drift-angle in collisions, by Drs. C. Schilling and H. Wiegand. Naccori Guis, Lezioni di astronomia nautica. Development of the ship's engine during the last decade, by Carl Busley. Cours d'astronomie pratique, par E. Caspari. Types des calculs nautique (Ecole navale). Index of periodicals. Bibliographie.

VOLUME XVII, NOS. 1 and 2. Two essays on torpedoes (Captain Grenfell, R. N., and Lieutenant-Commander Reisinger, U. S. N.). Study on the physical relations between the Black Sea and the sea of Azow. Steam manual for H. B. M. fleet (translated from the English). Estimate for the Italian navy for the fiscal year July 1, 1889, to July 1, 1890. Transportation of torpedo-boats on railroads (translated from U. S. Naval Intelligence Publication). Trials of torpedo-boats in Spain. Yarrow diverging torpedo-gun. New American torpedo. New torpedo-boat for the United States. Snyder's dynamite projectile. American cast-steel guns. Effect of melinite projectiles. Permanent log, Michel system. Regulation in regard to special firemen for the French navy. Byers and Storey's Reliance anchor.

Pugan's "cable anchor." New apparatus for throwing dynamite projectiles. Further experiments with cellulose. Method of discovering location of leaks in iron vessels. New vessels for the English navy. Establishment of "L'Association Technique Maritime" in France. Further firing experiments against the armor-clad Resistance. Laying of the keel of the protected cruiser of the third-class, Bartam. Defense of the mouths of English rivers. Defense of English coaling stations. The English torpedo-gunboat Sharpshooter. Torpedo-boats for India. The dynamite cruiser Vesuvius. U. S. cruiser Charleston. Steam launches for the Congo. New cruiser for Japan. New gunboat for Japan. Launching of the wrecking steamer Kraft. Mobilisation of French torpedo-boats. The Russian armored cruiser Imperator Nikolay I. Nourishment of shipwrecked persons on the open sea. Trial of the submarine boat Peral. Italian auxiliary fleet. Torpedo factory in Venice. Torpedo-nettings, Solomiac system. Accumulators with alkali fluids. Lowth's telephone. Examination of officers of the Austrian-Hungarian merchant marine. The motors used on the earth. Oil on the sea. Bridge across the English Channel. Aluminium bronze and other aluminium alloys. Literary reviews: The decisions of the courts in the collision of the Sophie and Hohenstauffen, by Dr. H. Wiegand. Use of fluid fuel for ships' boilers, by Karl Busley. The care of sick in the house and in the hospital, by Th. Billroth. Une page d'archéologie navale: les caboteurs et pêcheurs de la Tunisie, by Captain P. A. Hennique. Arms used in warfare, by Emil Capitaine and Ph. von Heotling. The last globus of Johannes Schäuer of 1523, by Dr. Franz R. von Wieser.

E. H. C. L.

PROCEEDINGS OF THE INSTITUTION OF CIVIL ENGINEERS, LONDON, 1889.

Friction-brake dynamometers; description, discussion, and correspondence. The friction of locomotive slide-valves. The speed trials of the latest additions to the Admiral class of British war-vessels, Camperdown and Anson.

Descriptions of hulls and machinery, and accounts of the trials, with curves of displacement, midship section, and indicated thrust; twisting movements on cranks, and tabulated particulars and results of trials, and plate of engines of Anson. F. H. E.

THE RAILROAD AND ENGINEERING JOURNAL.

FEBRUARY. The development of the military rifle (continued).

MARCH. Spirally welded tubes (illustrated).

APRIL. The development of the modern high-power rifle cannon. The latest English battle-ship, the Victoria (illustrated). F. H. E.

REVISTA MARITIMA BRAZILEIRA.

NOS. 1 TO 5, JULY TO NOVEMBER, 1888. War material manufactured in the pyrotechnic laboratory of Campinho, by Lieutenant

F. H. Ancora da Luz. Double tides in the bay of Rio Janeiro. Armored turrets. Military jurisprudence. Foreign chronicle.

J. B. B.

REVISTA MILITAR DE CHILE.

No. 27, December 1, 1888. Project for reorganization of the army, by Lt.-Col. Don J. C. Salvo. Study on field-artillery tactics, by Captain Don A. Fuenzalida. Considerations on the commissariat of an army, by Ensign C. L. C. The pneumatic gun (translation), by Sergeant-Major Don R. S. Goñi. Statistics of the armies and navies of European nations (translation), by Lt.-Col. R. V. O.

No. 28, January, 1889. Study on field-artillery tactics (conclusion), by Captain Don A. Fuenzalida. Fundamental principles of attack, and formations for attack with cavalry: principles demanded by the conditions of modern warfare, by Captain Don A. Fuenzalida. Suggestions for the formation of a permanent staff in the Chilian army, by a General Officer. On the proper disposition of cavalry (translation from the English), by Lt.-Colonel Don R. V. O. The pneumatic gun (conclusion), by Captain Don Benjamin Villareal.

No. 29, February. Carrier-pigeons (editorial), by Lt.-Colonel Don José de la C. Salvo. Experiments made in foreign countries on the reducing of gun calibers (translation), by Captain Don Recaredo Amengual. Disbanding of the northern garrisons, by Captain Don A. de la Cruz P. Prisons and military offenders, by Ensign Don C. L. C.

J. B. B.

REVUE DU CERCLE MILITAIRE.

January 20, 1889. The rôle of the three arms in battle, and the future armament of the infantry.

The increased range and precision of modern firearms, everybody admits, necessitate corresponding modifications in the special use of the three arms of the service. The object of the present article is to discuss the nature and extent of those modifications.

Instantaneous photography applied to military arts (illustrated). Naval architecture: II. Iron age (continued).

January 27. Russian army manœuvres combined with exercises in firing in battle. Instantaneous photography. Study of the resistance of air to the motion of projectiles. Naval architecture: III. The steel age (ended).

February 3. Machine and rapid-firing guns.

February 10. New regulations for infantry manœuvres in France. A military reconnaissance by Vauban, as related by himself. The Turkish straits' defenses (with map): I. The Dardanelles.

February 17. Shall the lance be restored to the cavalry? The Turkish straits: II. Constantinople; III. The Bosphorus.

February 24. The rights of nations in war times. An ascension of 3000 meters performed in three days with a mountain battery in the Caucasus. The Italian Alps fortifications.

MARCH 3. Instructions in night expeditions and attacks in the French army. The inspirators of Napoleon—Maillebois and Bourcet in Italy, 1733–1735. The communal militia in Italy.

MARCH 10. The German cavalry as judged by a Russian officer. Movable forts on the frontiers of France.

MARCH 17. Night drill and manœuvres: instruction of company and field officers. The Turkish army in 1889. Official returns of the medical department of the French army for 1885. Military centralization in Switzerland.

MARCH 24. The infantry musket in European armies.

Of all the questions engaging the minds of the military just now, none possesses more actuality and interest than that of the infantry armament. The majority of European powers have adopted the repeating rifle of small caliber. With respect to the mechanism, some have the magazine in the stock of the gun, others prefer the detachable magazine. The changes in the cartridge casing are trifling; but on account of the steep incline of the grooves, it has been necessary to abandon the soft lead bullet, and it has now a core of lead with a jacket of albata, copper or steel. Owing to the great initial velocities sought, powder plays a very important part. France has a powder, "Vieille," of pyroxyline and collodion, smokeless, giving a velocity of 640 m. England has an almost smokeless powder with a velocity of 565 m. In Germany, the Rottweil-Hamburg factory has succeeded in manufacturing a powder nearly equal to that of the French.

The equine species and its amelioration in France. Night drill and manœuvres in the army, with historical examples of night operations (ended). Adoption of the Mannlicher gun of 8 mm. (small caliber) in the German army. J. L.

REVUE MARITIME ET COLONIALE.

FEBRUARY, 1889.

The interesting and instructive article on Tourville and the navy in his time, with notes, letters, and documents (1642–1701), is continued in this number. It consists in most part of correspondence borrowed from the Archives de la Marine, to which the writer had easy access.

Notes on the course of the Niger between Manambugu and Timbucktu. The double moulinet-log and its appliances, with illustrated description, by Captain Fleurçois. Scientific mission to Cape Horn (1882–1883); a history of the expedition. Hydrography. A study of submarine boats (memoir presented to the Academy of Sciences). Naval chronicles.

APRIL. Historical studies of the French military marine. Fleet operations during the administration of Colbert.

The above studies, which have appeared periodically in the Review since 1886, are ended in this number. They present very interesting and instructive reading.

Tourville and the navy of his time, with notes, letters, and documents, 1642–1701 (continued). The Gulf of Gabès (Tunis) fishery. Notes on the life of Chevalier De Langle, lieutenant of Lapérouse in his voyages of discovery.

De Langle with a party of sailors was treacherously massacred by the savages of the island of Tutuila (Samoa), and their bones now rest in the French chapel on the island.

Principles of the economy of navigation (a valuable professional article). A notice on the course of the Niger, with a table of astronomical calculations. Programme of naval constructions in England. Breaking up on the spot of condemned ships. Increase of the U. S. Navy. The dangers of automatic guns. Comparative strength of the armaments of the most recent war-ships. Accidents during gun practice. Report of the arbitrators of the late English manœuvres. Corrosion of steel hulls. Use of the pistol for signaling at sea. The U. S. torpedo-boat Gatling. An English torpedo-boat burning liquid fuel. A steel wire-wound gun with a range of 20 kilom. in England. The forts of the Meuse in Belgium.

April 7. Summary of No. 14. Participation of the reserves in the storming of strongholds (infantry tactics).

The line of attack should be supported by the reserve in column, to take the place of the former after entering the position, in order to repulse an offensive return, etc.

Night manœuvres before Kertch.

The conviction is gaining ground in Russia as well as elsewhere of the importance of night operations, and the consequent necessity of night drill.

April 14. The actual rôle of fortified places. The new uniform of the Alpine troops (with illustrations). J. L.

RIVISTA DI ARTIGLIERIA E GENIO.

Vol. IV, November, 1888. Experiments with concrete for building fortifications, by F. Lo Forte, major of engineers. On disinfecting apparatus, by Dr. G. Mendini. On the tactics and equipment of mitrailleuses (translation from English), by Captain Podestà Giulio. Miscellany: French gun-carriages, Vavasseur system; The new French repeating rifle; Telemeter with vertical base; Certain phenomena of explosions; Aluminum shields for defense of infantry against small-arm fire. Foreign chronicle. J. B. B.

RIVISTA MARITTIMA.

January, 1889. Indicator for determining relative and absolute speed of opposing ships; theoretical and practical development (with plates), by Captain D. Bonamico.

The scope of the indicator is the determination of the absolute and relative speed of a ship in all cases that may arise under the ordinary conditions of steam navigation. A favorable preliminary report has been made, and the Italian ministry has ordered that indicators be placed for further trial on three cruising ships of different types.

The port of Marseilles (with plates showing in full the system of docks, basins, breakwater, method of construction, etc.), by E. Borgatti. Foreign chronicle.

FEBRUARY. The port of Marseilles (continued), by E. Borgatti. Torpedo tactics in offensive and defensive wars (with diagrams); (translation from Prize Essay, Proc. N. I.). Maritime warfare in the future (translation), by Geffcken, from the *Revue de droit international.* J. B. B.

ROYAL ARTILLERY INSTITUTION.

FEBRUARY. Outline of an instrument for measuring deflection corrections, firing at moving objects.

MARCH. A discussion on the disadvantages of too high a muzzle velocity for field guns.

Puts limit at about 1500 f. s. Neglects the advantages of a flatter trajectory. M. K. E.

SCHOOL OF MINES QUARTERLY, NEW YORK.

JANUARY, 1889. The transformation of electricity into mechanical energy. Notes on some chemical qualities of foundry irons. F. H. E.

UNITED SERVICE GAZETTE.

MARCH 23. Experiments with the Resistance.

She was provided with steel curved deck and gun-shields. Experts considered the guns to have had the best of it.

APRIL 6. A plan of reorganization of the fleet.

Each ironclad in a squadron to be accompanied by (1) at least two first-class sea-going torpedo-boats; (2) a fast turbine gunboat ram, as a rule in tow, fitted with search lights and mine-removing apparatus; (3) a very fast 200-ton turnabout torpedo-boat catcher. Each squadron to have at least 4 colliers.

APRIL 13. Designs for new battle-ships. M. K. E.

LE YACHT.

JANUARY 26, 1889. A tactical study of ships of war. Review of the merchant marine of the world. Description of an electrical twin-screw launch of twelve tons (with illustration). New vessels building in Europe. Speed trials, etc.

FEBRUARY 2. Editorial on the French navy; a new law relating to the engineers, the colonial policy. The bursting of the gun on board the Amiral-Duperré, etc. A tactical study of ships of war (continued). Stations of ships of the French navy in commission.

FEBRUARY 9. Discussion on the German navy in the Reichstag. A tactical study of ships of war (continued). Plans and description of Le Courbet, armored ship of 10,518 tons displacement.

FEBRUARY 16. Editorial on the defenses of Cherbourg. The World's Exhibition of 1889 (with plan). Review of "La Marine Militaire" (1888–1890), by Emile Weyl. Review of the merchant marine of the world. The U. S. Navy.

FEBRUARY 23. A discussion of forced draft. Notes from foreign shipyards. A practical study of the development of the catamaran.

MARCH 2. Editorial on the English navy. Lord Brassey's views. A practical study of the development of the catamaran (with illustrations). Description and plans of Le Formidable, French battle-ship. Artillery practice near Havre; trial of guns (Canet system) before the Japanese military commission.

MARCH 9. Editorial on the official report of the autumn manœuvres in England. The capsizing of torpedo-boat No. 102 in the bay of St. Nazarre (with chart). A practical study of the development of the catamaran (continued, with illustrations).

MARCH 23. The programme of the English Admiralty for this year. Description of the White Star steamer Teulome (with view). A practical study of the development of the catamaran (continued, with illustrations). A letter relating to the stability of torpedo-boat No. 102.

MARCH 30. Editorial on naval matters in France. The loss of torpedo-boat No. 110. Review of the merchant marine of the world. The Naval Reserve in France. A practical study of the development of the catamaran (continued, with illustrations).

APRIL 6. Editorial on the loss of torpedo-boat No. 110. The Samoan disaster. The future of the submarine torpedo-boat. The ventilation on board the Formidable (with plan).

APRIL 13. Notes from foreign navy-yards. A new type of triple-expansion engines (with plans). Modifications proposed in a torpedo-boat of 35 meters, suggested by the loss of Nos. 102 and 110 of that class.

A. C. B.

REVIEWERS AND TRANSLATORS.

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THE PROCEEDINGS

OF THE

UNITED STATES NAVAL INSTITUTE.

Vol. XIII., No. 3. **1887.** **Whole No. 42.**

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PRIZE ESSAY FOR 1887.

"*In hoc signo vinces.*"

THE NAVAL BRIGADE: ITS ORGANIZATION, EQUIPMENT, AND TACTICS.

BY LIEUTENANT C. T. HUTCHINS, U. S. Navy.

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I.—Organization.

To be successful in the landing of seamen and marines and in the operations on shore of the naval brigade, much will depend upon the previous system of organization and training of the personnel that will compose the force. The fact must not be lost sight of, that upon the amount of work in the care and preparation of the seaman to meet the requirements of detached service will his efficiency be measured.

To fulfill the demands of a hastily assembled fleet, with battalion organizations sometimes very dissimilar, and to unite the different ships' battalions into a homogeneous military force for landing, must, under the most favorable circumstances, prove a difficult task.

There has been, and probably always will be, some objection by naval men to the naval brigade and the landing of sailors for operations on shore. The legitimate sphere of the seaman being afloat, the landing of a naval force cannot be otherwise than incidental to the service. Any attempt to organize a ship's company with the infantry battalion as a basis would probably result in confusion and disaster; to return to the days of the Invincible Armada and fill our ships with soldiers would be folly.

Under our system of government and the growing opposition to a large standing army, it must be apparent to the most conservative that the naval brigade is a pressing necessity.

The demand for landing parties from our ships and fleets, both at home and abroad, was shown during the labor riots in this country in 1877, at Alexandria, Egypt, in 1882, and more recently on the Isthmus of Panama in 1885. The organization and transportation to the Isthmus of Panama of a naval force in April of that year demands more than a passing notice. As a measure of quick despatch, economy, and the efficient work performed, the accomplishment of the desired results on this occasion was more than satisfactory, and a progressive and enterprising people like ours will never fail to lend support to a force which with the least expenditure of time and money accomplishes the desired work.

We still find some opposition on shipboard to-day among sailors to being landed as infantry; the growing and constant desire to turn the sailor completely into a soldier at these times, and his invariable opposition to this transformation, is the cause of want of success and lack of interest. But this opposition of the sailor may be easily overcome by judicious treatment, emulation, and a system of competition, not only between companies in ships' battalions, but between different ships; and with this interest once awakened, the regular landing day would be hailed with delight. No valid reason is apparent why the naval brigade should interfere with great guns or the marlinspike, if we stop what is known in the Navy to-day as show drills, theatrical in their effect and forced on the Navy by long custom. The absolute niceties of the soldier should be abolished in the drills of the ship's battalion. The time devoted to these unbusiness-like evolutions should be employed to some useful purpose, and the sailor not subjected to the strait-jacket drill every infantry day. Every ship's battalion should be landed frequently when in port, authorities and weather permitting. Once a week would not be too frequent for a cruising ship, and the brigade should be landed for several days in succession when the Admiral assembles his fleet for drill and inspection.

To land the naval brigade in opposition to well-organized and trained forces of infantry would not be expedient, but that a naval force would prove more than a match for any but regular soldiers none can doubt. For street fighting, the trained seaman may be considered quite equal to the regular soldier. The economy of time in the transportation of a naval brigade along the seaboard or on our large rivers, thus avoiding any opposition a force would meet with in having to pass through cities to destination by rail, and its being ever ready, must make such a force always a desirable one. What sailors can accomplish when landed to co-operate with an army was well illustrated during the Franco-Prussian war, by the French seamen at the siege of Paris as artillerymen, and at Le Bourget as infantrymen. England, with her small standing army, has of late years placed great reliance upon her naval brigade. The conduct of her sailors and marines in the Ashantee war of 1873, and in Egypt and the Soudan in 1884, merits the greatest praise. One of the most brilliant exploits of a naval force was the landing of the naval brigade of the French fleet and taking of Sfax in July, 1881, when the electric light and the 1-pound Hotchkiss shell gun, mounted in ships' boats, were brought into use.

The Watch, Quarter, and Station Bills now supplied to all our naval vessels, call for a battalion with an officer to command called "Colonel Commanding," also other necessary officers. The battalion is composed of, first, the artillery, with an officer to command, each piece being in charge of a junior officer with a quarter gunner. Then follows the marine guard, forming the first company; next, the seamen forming the other companies, and last, the pioneers. This arrangement appears to work fairly well in the service, though in some vessels there are ammunition passers and carriers, and stretchermen to care for the wounded.

The term naval brigade is now applied to the battalions of two or more ships brigaded together for the purpose of landing for operations on shore. In uniting the different battalions under one head, each ship's battalion should land and fall in together; no separation of the companies of a battalion should be allowed if it can be avoided. In forming the brigade for exercise and drill, the music should form on the right of the line; then should follow the artillery battalion; next in order the first battalion of infantry, made up of the first company of marines, "Co. A," the second company of marines, "Co. B," etc.; then the second battalion of infantry, made up of the first company of sailors, "No. 1" company, the second company of sailors, "No. 2" company; next, the third battalion of infantry, and so on; and, last, pioneers and stretchermen—bearing in mind that all the artillery of the force are to be kept together, as well as the companies of marines and the companies of sailors. Any division or breaking up of the full companies of marines, or of the companies composed of seamen of a ship's battalion, should not be thought of; men that are known to each other should be allowed to go into battle together and under their own company officers.

The great feeling of pride in one's own ship should be cultivated to the fullest extent, hence the necessity of keeping ships' battalions as intact as possible. In naming the companies, it will be seen that the marines have their companies distinguished by letters and the sailors their companies by numbers, which numbers in a ship's battalion are the same as those of their respective divisions, No. 1 company coming from the first division, and so on. Again, a numbered company would indicate that the company was composed of seamen.

A company of infantry should be composed of 40 men, with 2 guides, 2 file-closers, and 2 ammunition passers and carriers — in all 46 men. Companies should not be too large and unwieldy; large companies could only be a question of economy of officers, and in this matter no navy to-day can afford to be wanting. A division should, if possible, furnish a company of infantry, except the master's division; and the company should be commanded by the division officer, one of the junior officers of the division being associated with him. In small ships this may not be at all times possible, but when unable to do so, the engineer's division would be merged in the powder division. The high-powered breech-loading rifle and rapid-firing cannon worked by small gun's crews must necessitate an increase in the number of men, and greater intelligence in the powder divisions of our ships, if they are to be efficient; servants and bandsmen will have to be eliminated and better men must take their places: therefore, with a more capable and much larger powder division, one infantry company could be selected from it in large ships. The chief aim must be to have the companies commanded by their own division officers, with whom they are familiar as well as known.

Too much stress cannot be laid upon the fact that the hasty assembling of a naval force for landing, under strange officers to command, can be but ill-advised. Officers should know the men who are to serve under them, and this can only be accomplished by organizing the force under the officers of the ships to which the men belong and to whom they are known. The commander of the naval brigade and his staff could come from any station or ship, but the company officers should come with the men from the same vessel. A writer on the naval expedition to the Isthmus of Panama in April, 1885, complains of the difficulty encountered under the present system of transfer papers in the selection of good men to fill ratings, especially in an emergency such as the hurried fitting out of an expedition. It will be seen that this difficulty can be avoided by landing men under command of the officers of their own ships. For another writer on the same subject, speaking of the landing of the naval brigade of the North Atlantic Squadron at Gardiner's Bay in August, 1884, with officers and men from the same vessels, says: "It was noticeable that the sergeants and corporals chosen from the *petty officers* and *leading men* performed their duties with intelligence and force. Another fact was apparent: the men who were most distinguished as *seamen* were, as a rule, more prompt and exact in their duties on shore."

In every ship's battalion of two companies of infantry and one company of artillery there should be allowed four ammunition passers and carriers, four pioneers—composed of one blacksmith, one armorer, one carpenter, and one fireman—two stretchermen, one bugler, and two signalmen, with a bayman allowed to the medical officer. On drill days two markers and one drummer will land with the battalion; markers and drummers are of no use whatever in actual service, and should not be taken.

The officers of the ship's battalion would be as follows:

An officer (the Executive) to command battalion.
Company officers.
Adjutant.
Commissary, who will also act as Quartermaster.
Surgeon.
Gunner, with large battalions.
A Junior Officer, when Gunner is not allowed.

The commanding officer of the naval brigade should do his utmost to obtain a band; nothing adds so much to the pleasure of the men, nor aids more to make them contented and cheerful. The band should be armed with rifles and drilled; there are too many noncombatants on shipboard at the present day, and the sooner an effort is made to do away with this state of affairs the better for the service.

I unhesitatingly say that the powder division, engineer's force, music, and all servants, except perhaps the stewards and cooks, should be drilled in the use of the rifle; more particularly in the firings, loadings, and facings. A company of artillery should consist of 16 men, and the men selected for the pieces should come from the larger pivot guns or master's division; preferably the first four men from the latter, if they are accustomed to work and fight these guns on shipboard. The divisional officers from the pivot guns command the sections, junior officers the pieces.

The landing of artillery should generally be limited to the 3-inch breech-loading rifle, the Hotchkiss revolving cannon, the single barrel Hotchkiss, and the Gatling. Smooth-bore howitzers have had their day and they should not be landed. The guns should be manned by large crews, capable of taking with them plenty of ammunition. Too many guns should not be landed, as they hinder the movements of a force and are always a heavy burden. A naval brigade that is thoroughly organized and trained needs but few pieces of artillery. It can be said that we have arrived at that state in the Navy when we are unable to say just how many pieces of artillery should be landed. It would seem far better to land a few guns with large crews and plenty of ammunition; care being taken to keep similar guns together, so as to avoid confusion with the ammunition. Ammunition boxes and wagons should be painted the same color as the gun carriages and limbers, and they should also be numbered. It must be remembered in landing artillery that the nature of the service will always be a great consideration, as well as the difficulties to be encountered in transportation of ammunition for the rapid-firing cannon. All the artillery should have limbers, when 7 additional men would be added to each of the gun's crew, making a crew up to 23 men for gun and limber.

By reducing the number of guns and increasing the number of men in the crews, adding limbers to each gun to carry the large amount of ammunition now required, more efficiency will be gained, and about the same number of men would be landed in a ship's battalion. In small ships one piece of artillery should be landed with the battalion, in the larger ones two pieces. In combining the battalions of a fleet and forming the brigade, more guns would be found than necessary; but as the crews of two guns combined form one company, they could be landed as such if desired, from those ships that would under ordinary circumstances land two pieces of artillery with limbers.

The ordnance manual already requires that the crews of the howitzers and machine guns shall be united so as to form an infantry company and be drilled as such. At the present time, vessels in our service do not land men often enough as infantry. More arms should be supplied to vessels, and one company be selected from each of the powder and engineer's divisions in large ships, and in small ships one company from the two divisions combined. Then in a vessel of the Atlanta class we would have from the crew 2 companies, 92 men, and two guns and limbers, 46 men, 4 pioneers, 4 ammunition passers and carriers, 2 stretchermen, 2 signalmen, and 1 bayman, in all 151, out of a complement of 242 men, not including the marine guard, which would probably land 37 men, making a total of 188. After landing so large a number of men from a vessel of the Atlanta class, there would be left on board 3 men belonging to the marine guard, 26 men belonging to the main battery, 13 men belonging to the secondary battery, and 52 men belonging to the powder and engineer's division combined, total 94 men; a force, with the modern improvements on ships, still large enough to fight and work the vessel. One company of infantry would come from the main battery, one company from the powder and engineer's division combined, and two companies of artillery from the secondary battery, the men from the secondary battery being accustomed to work the machine guns.

The landing of so many men may be considered an innovation on the practice of the service, but it will be seen that the circumstances governing the work required of the ship during the absence of the battalion would decide if all of the force or a certain number of companies should be landed. If the artillery is landed without the limbers, large gun's crews would still be required to carry the ammunition for the machine guns. Still the necessity must be apparent to every one that both the howitzer rifles and machine guns should be fitted with limbers. The men selected to work the machine and rapid-firing guns should be carefully and well drilled, noted for their high standard of intelligence, coolness under fire, and specially alert; the first five men of the crew should be good marksmen, equally well trained. They should be armed and able to defend their guns in the event of a jam occurring in the mechanism and the enemy coming to close quarters. Care should be taken that the ammunition is not separated from the guns, and that guns of the same kind are kept together. Some of the machine guns of the English Naval Brigade in the Soudan failed at the most critical moment, and the failure of the machine guns in the French army during the Franco-German war was due to the want of men thoroughly trained in their use. The value of the machine gun cannot be overestimated, when it is properly served; and to serve the gun with any degree of success, constant and frequent drills must be carried on and the rapidity of fire determined by practice. Cartridges sometimes hang fire, and in the presence of an enemy, under excitement, fast firing might be a source of great danger; no pains should be spared in the instruction of the seamen in target firing, the most important of all drills in the Navy.

Combining the units, the ships' battalions, and forming the brigade, we would find, say with a force of twenty companies of infantry: ten pieces of artillery, total infantry 880 men; artillery, 230 men; there would be 40 ammunition passers and carriers, 30 pioneers, 25 stretchermen, 10 buglers, 8 signalmen, 1 master-at-arms or 1 ship's corporal, 15 cooks when in encampment, and 3 apothecaries. It will be seen that 10 pioneers have been eliminated in the combination, also 5 baymen and 12 signalmen. These men could be drawn from to fill vacancies, or be used to carry camp equipage, ammunition, and handling rations and stores, the signalmen leaving their kits behind; or they could be turned over to the beach-master at the landing place of the brigade.

The apothecaries and stretchermen, and they alone, are to care for the sick and wounded; and it must be impressed on the minds of the men that they are never to leave the ranks in battle to assist the wounded. Apothecaries, baymen and stretchermen, with the medical officers, are the non-combatants. Two medical officers should be allowed to the brigade, one being on the staff. An officer should be detailed as signal officer. One gunner would have charge of the ammunition for the infantry, and another of the ammunition for the artillery. A gunner or gunner's mate should be sent with every ship's battalion when landed. The gunner's mates, pack animals, ammunition, and ammunition carts, if provided, should all be under the command of a capable and energetic commissioned officer. Pioneers on the field of battle will assist the ammunition passers, and when the supply of ammunition is exhausted, both they and the ammunition passers and carriers should be ordered to take a rifle and cartridges from any wounded men and join the fighting line. To fill casualties among the ammunition passers and carriers, their places should be filled by men selected from the companies to which they belong. Two carpenters should be detailed with the pioneers.

Marines.—The legitimate duties of the marine corps being those that pertain to soldiering, their organization, equipment and tactics should be all that can be desired. The guards of most vessels being of necessity very small, the combination of two or more is required to form an infantry company, which should be, if possible, numerically the same as a company of seamen. Signal being made, the different guards would be organized into companies with their officers on convenient ships of the assembled fleet, and landed in separate boats pulled by sailors. The companies of marines should be as near like the companies of seamen in their organization as circumstances will permit. Allowing 5 companies of marines in a brigade of total 25 companies of infantry, the 10 pioneers that have been eliminated in the combination could be detailed as ammunition passers and carriers, and 5 baymen as stretchermen.

The total force of marines—5 companies—would be 220 men rank and file, 10 ammunition passers and carriers, 5 stretchermen and 5 buglers.

Officers.—One officer of suitable rank to command battalion.
Adjutant.
One Aide.
Five Captains of companies.
Five Lieutenants of companies.

Intelligence Staff.—Much attention should be given to obtaining information of the movements, plans, and the number of the enemy. To obtain all possible information without the enemy being aware of the fact is a great point gained in actual warfare.

An Intelligence Staff, selected, if desired, from the intelligence officers of the fleet, should land with the brigade. When an expedition is fitted out and sails from the United States, this staff could come from the Naval Intelligence Office, Washington. This staff should be composed of two officers with their outfit and necessary assistants, their strength depending very much upon the mission they are to fulfill. They should come under the immediate command of the Adjutant General of the brigade or Chief of Staff. Their duties must not be confounded with the duties of the signal staff, the work of the latter pertaining more to keeping up constant communication between reconnoitering parties and the main body, or between the main body and fleet. No matter how small the force, an intelligence officer should accompany the landing party. The great necessity for such a staff was shown at Alexandria, Egypt, during the bombardment of that city by the English fleet, 1882, and more particularly after the landing of the English naval brigade.

The frequent preparation of the English landing force for a threatened attack, and unreliable information as to the movements and whereabouts of the enemy, very much crippled their force thrown on shore there to protect the city, costing loss of life and very considerable loss of property by fire.

The Field and Staff Officers of the naval brigade should be as follows:

An officer of suitable rank to command the brigade.
An officer to command each battalion, and one aide.
Brigade Staff.—One Adjutant General (also Chief of Staff).
One Ordnance Officer, who also acts as Military Engineer.
One Quartermaster and Commissary.
One Signal Officer.
One Surgeon.
Two Aides to commander of brigade.
Intelligence Staff.—Two officers.

Sanitary Precautions.—In spite of science and modern inventions to destroy men in battle, the fact still remains that disease carries off more men than all other causes together. No pains should therefore be spared to provide for the proper treatment of the sick and wounded. When not in the presence of an enemy, the first consideration in pitching a camp should be sanitary conditions of the ground.

A code of instructions guarding against prevalent diseases, and emanating from the senior medical officer of the brigade, should be followed as closely as possible. Men should sleep in their shirts and drawers, their shoes, stockings and outer clothing being removed. In throwing up entrenchments and bivouacking on new-made ground, the health of the officers and men will be greatly increased if they have something to sleep on. The ventilation of tents should be carefully attended to and no crowding be permitted. When in encampment, tents should be struck frequently in fine weather to allow the sun to dry the ground occupied by them. No orders preventing men from committing nuisances in camp can be too strict. In entering on an expedition, if possible, such seasons of the year should be selected as will favor the health of the men; and it would be well to bear in mind the frequent moving of the brigade to new camping grounds. A very liberal supply of medicines and food should be provided for the sick and wounded.

It cannot be doubted for an instant that we are sadly in need of transport vessels for use of both the Army and Navy. After the landing of a naval force from transports, the vessels could be used as a base of supplies and for hospitals.

In the *preparation of orders* for the brigade the following points should be well considered, the commander of the brigade defining the duties and responsibilities of each officer, and his subordinates:

1st. Object of expedition and probable length of time on shore.

2d. Number of each arm of the service, infantry and artillery, to be landed.

3d. Rendezvous for boats.

4th. Map of "order before landing," with the position of each boat and covering vessel marked thereon.

5th. Number of covering vessels.

6th. Name of ordnance vessel, hospital ship, provision ship.

7th. Number of artillery boats to assist to clear beach and not to land.

8th. What articles each boat is to carry.

9th. Number of days' provisions men are to carry.

10th. Number of battalions and by whom commanded.

11th. Officer to command at beach.

12th. Number of rounds of ammunition that each man is to carry.

13th. Amount of spare ammunition required.

14th. The distance of objects on shore from the beach, for use of covering vessels and artillery boats.

15th. Order of formation of the line of battle on shore.

16th. What men are to carry, provisions, ammunition, clothing, etc., and what articles are to be left in the boats.

17th. If spare ammunition, water, stoves, etc., are to be landed from covering vessels or to be kept in boats at landing.

18th. If entrenchments are to be thrown up by beach-master, and if he is to have any of the heavy guns landed for armament.

19th. State of tide, depth of water, and the nature of the bottom.

The commanding officer of the brigade should receive his orders in writing from the admiral, or senior officer present, or when an expedition sails from the United States, from the Secretary of the Navy; but he should not be hampered by instructions and petty details in the former case.

The battalion commanders and the beach-master should receive their orders or instructions from the commander of the brigade, through the chief of staff, or adjutant general, and in no other manner.

II.—EQUIPMENT.

The equipment of sailors landed from our ships for operations on shore should not be a matter of individual whim or fancy. There should be no sparing of criticism until we have attained uniformity in the combination of the guns' crews and the battalions of a fleet of vessels meeting even for the first time. The breech-loading magazine rifle, with which every naval brigade should now be equipped, brings before us the problem of the supply of ammunition to the fighting line.

Firings will begin at longer distances, and with the continued advance at the most critical moment the men may be without ammunition; to guard against such a catastrophe will be one of the most difficult services required of us. To meet this requirement a considerable force will be wanted to carry and pass ammunition, which can only be attained by reducing the size of the infantry companies. On an extended march horses and wagons would have to be pressed into service, when the ammunition passers and carriers would make up the ammunition train, converting any wagons obtained into ammunition wagons. A small wagon, fitted for one horse, and also with a drag-rope, the wheels being the same as those for the artillery wagons, should be furnished each ship in the service that would land two companies of infantry and one piece of artillery. This wagon would be used for the transportation of extra ammunition, mess gear or camp equipage. Ammunition passers and carriers will always be a necessity, either to carry ammunition on the march or to supply the fighting line in battle. There appears to be a considerable difference of opinion as to how the naval brigade should be armed, but the weight of authority would seem to favor arming every man with a rifle that could carry one. In the artillery companies the first 7 men of the guns' crews should be armed with large-size navy revolvers of the latest pattern. Cutlasses should be discarded, as they are of no earthly use; the remaining men at the gun should be armed with rifles. Should limbers be landed with guns, 13 men would go with the gun and 10 men with the limber. In fitting limbers for the artillery the wheels should be exactly the same as those for the gun carriage, being interchangeable; all wheels to have broad treads, that they may be serviceable in sandy and marshy ground. The first 3 men of each limber's crew are to be armed with revolvers and the others with rifles, all rifles to be fitted with slings to go over men's backs. In case of a jam in the mechanism of a piece which would render it liable to be taken by an enemy, the riflemen would be prepared to prevent a capture. By introducing light shields the fighting power of the artillery might be improved. Shields weighing about 5 pounds to the square foot could be fitted to the gun carriages, and admit of easy transportation. Pioneers will be armed with large-size navy revolvers, and carry implements for entrenching and cutting road-ways. Every man armed with a rifle, except men belonging to the artillery, should carry 80 rounds of ammunition. In the artillery the men armed with rifles will carry 40 rounds, and those armed with revolvers 60 rounds of ammunition.

Two orders of marching will be used in this paper, *Light Marching Order* and *Heavy Marching Order*. I have given the amount of ammunition to be carried by the latter; the former would carry half of this amount, as seen in the accompanying tables. These two "marching orders" should be used throughout the service, and the articles to be carried in each should be specified in the orders of the fleet, that it may be known on each ship how her battalion is to be equipped on receiving a signal to land.

Officers should be armed with a sword and revolver—large size—though it may be a question open to discussion if the days of the former are not numbered. The sword as a badge of office may serve its purpose, but for actual war it is a useless appendage. An improved magazine gun fitted with slings, and not too heavy, would be very useful for all officers of companies.

The sword bayonet is too heavy and clumsy; a light, well-made bayonet should be supplied. Cartridge boxes, belts, and pouches for carrying ammunition should have straps to support them from the shoulders; when not supplied, the straps can be made on shipboard of canvas, crossed at the back like suspenders. The handiest belt now in use for carrying cartridges is the Mills web belt, which seems to answer every purpose in the Army, when the one that is worn around the waist is fitted with shoulder straps. Extra belts can be filled with cartridges and packed away in canvas bags to be served out in an emergency. The emergency having passed, they would be turned in again. These extra belts should be worn over the left shoulder. Every officer and man should carry a blanket; the men's blankets should be rolled in a canvas or waterproof sheet strapped together and slung over the left shoulder and retained there by a loop. Rolled in the blanket should be a woolen shirt, a pair of woolen stockings, and a towel.

There is no reason why men should not be furnished with light canvas knapsacks for carrying blankets and clothing; experience teaches us that without them there is little comfort either in the camp or on the march. Canteens should be carried by every one; if unable to obtain them, common bottles covered with canvas and fitted with slings will carry sufficient drinking water. Every man will carry a mess pan, pot and spoon slung to his belt or in his knapsack.

Ships' sails and the boats' sails make very good tents; capstan bars, boats' masts and oars being used for tent poles. For a prolonged stay on shore, application for tents to be supplied from the Army would be better; though there is no reason why each vessel in the Navy should not carry several tents instead of so many useless and spare sails.

The ammunition passers and carriers should be equipped each with two canvas bags, one worn over each shoulder; the bags containing 100 rounds of ammunition each, and weighing 11 pounds; this would give 22 pounds weight to each carrier. Should no pack animals or carts be available for the spare ammunition, large ammunition bags would be required, each one capable of holding two of the smaller bags—200 rounds. These large bags will be strapped with leather, each strap having two loops or rings, through which should be run poles; the poles should also have wide straps a short distance from the ends to go over the carriers' shoulders, and of the proper length to permit them to be grasped by the hands. The total weight for two men to carry would be 46 pounds (400 rounds of ammunition). Ammunition passers and carriers are not armed. Buglers and signalmen will be armed with rifles fitted with leather slings. Signalmen will also carry kits. All the medical force should wear the red Geneva cross and carry a flag (white with red cross), to be displayed from any field hospital or building that may be in use. None of the force will be armed except the medical officers, who will wear their swords only. The master-at-arms and ship's corporal will be armed with the navy revolver and carry 20 rounds of ammunition each.

Dress.—Officers' dress should be the uniform blouse; underneath the blouse a strap should cross the body, passing over the right shoulder to support the sword; woolen shirt, blue trousers, and brown leggings fitted with a lacing—buckles are a nuisance.

The head-dress for both officers and men should be the uniform cap, and in hot climates the helmet and canvas hat; a curtain to shade the back of the neck would also be useful. Every one should wear brown leggings that come well above the calf of the leg so that they cannot slip down. White short leggings may look well on drill, but in active service they are liable to slip down when wet, and they also make a good target for the enemy.

The new white canvas hat now issued to the men should be dyed brown for active service on shore. Everybody should have two undershirts and two pairs of socks — underclothing and stockings should be of wool—woolen stockings are indispensable on the march. If necessary, officers should provide themselves with overcoats and the men with pea-coats; and each should have a piece of painted canvas or waterproof sheet to sleep on. When tents are carried, a ship's tarpaulin thrown on the ground makes an admirable bed. When transportation can be obtained, officers' and men's effects could be carried in ship's bags that will keep out the water; one bag to an officer, and one to every three men, the latter messing and sleeping together.

Officers and men should bear in mind that any white articles of dress are conspicuous marks and are sure to draw the fire of an enemy's riflemen.

The brigade commander and staff should be mounted, if horses are obtainable, as also the commanding officers of battalions and staff. When the brigade is under fire all mounted officers would dismount.

Gun-cotton or some kindred explosive should be supplied to ships, and issued to the landing force for the purpose of blowing up buildings, furnished in 20 or 25 pound kegs, with outfit for firing. In the defense of buildings, or of an entrenched position hastily taken on landing—anticipating an attack—by placing several kegs of explosive material at the points most likely to be assailed, great assistance would be given to the defense. Gun-cotton was used with good effect at Alexandria, Egypt, by the English naval brigade to destroy buildings and prevent the spread of the terrible conflagration that raged after the bombardment of that city in July, 1882; while the attempt of the American fleet to land powder in tanks and carry it through the streets with burning buildings on either side was not a success — in point of fact, the attempt was abandoned.

Armed Cars.—It may frequently occur that armed railroad cars can be made use of by landing parties, such as flat cars fitted for carrying light guns, with boiler plates and sand bags for the protection of the crews.

When a force is landed to occupy a city, or no march is contemplated, 100 rounds of ammunition should be carried by the infantry, and 80 rounds of revolver ammunition by the artillery.

WEIGHT OF ARTICLES CARRIED BY MEN.

INFANTRY.

Light Marching Order.

	Pounds.	Ounces.
Waist-belt, bayonet and scabbard	3	12½
40 cartridges	3	14
Rifle (Lee magazine, long barrel)	9	
Haversack and two days' rations	5	15¾
Canteen, filled	4	4¼
Pot, spoon, pan, knife	1	4
Blanket roll, containing one undershirt, soap, towel, comb, one pair stockings	4	11½
Tobacco		3?
Total	33	1
Articles worn by Infantry (weight)	7	8

Heavy Marching Order.

	Pounds.	Ounces.
Waist-belt, bayonet and scabbard	3	12½
One belt, over left shoulder	1	
80 cartridges	7	12
Rifle (Lee magazine, long barrel)	9	
Haversack and two days' rations	5	15¾
Canteen, filled	4	4¼
Pot, spoon, pan, knife	1	4
Blanket, rubber poncho, towel, soap, comb, one undershirt, one pair stockings, pea-coat	11	13¼
Knapsack	2	2½
Tobacco		3?
Total	47	3¼
Articles worn (weight)	7	8

Artillery.

Light Marching Order.

	Pounds.	Ounces.
Waist-belt, revolver and 40 cartridges	4	12
Haversack and two days' rations	5	15¾
Canteen, filled	4	4¼
Pot, spoon, pan, knife	1	4
Blanket roll	4	11½
Accoutrements	2	4
Tobacco		3?
Total	23	6½
Articles worn (weight)	7	8

Heavy Marching Order.

	Pounds.	Ounces.
Waist-belt, revolver and 60 cartridges	5	6
Haversack and two days' rations	5	15¾
Canteen, filled	4	4¼
Pot, spoon, pan, knife	1	4
Blanket, rubber poncho, towel, soap, comb, one undershirt, one pair stockings, pea-coat	11	13¼
Knapsack	2	2½
Tobacco		3?
Total	31	0¾

Riflemen with Artillery.

Light Marching Order.

	Pounds.	Ounces.
Waist-belt, 20 cartridges	4	5¼
Rifle (Lee magazine, short barrel)	8	12
Haversack and two days' rations	5	15¾
Canteen, filled	4	4¼
Pot, spoon, pan, knife	1	4
Blanket roll	4	11½
Tobacco		3?
Total	29	7¾

Heavy Marching Order.

	Pounds.	Ounces.
Waist-belt, 40 cartridges	6	4¼
Rifle (Lee magazine, short barrel)	8	12
Haversack and two days' rations	5	15¾
Canteen, filled	4	4¼
Pot, spoon, pan, knife	1	4
Blanket, rubber poncho, etc.	11	13¼
Knapsack	2	2½
Tobacco		3?
Total	40	11

Thirteen men of each artillery company are armed with rifles, but without bayonets.

One hundred men would require the following rations for two days on shore: a total of 465 pounds 10 ounces, divided as follows, each man carrying 1 pound of pork, cooked, 1 pound of beef, cooked, 2 pounds of bread, 4 ounces of sugar, 2½ ounces of coffee, 4 ounces of beans, cooked. Total, 4 pounds 10½ ounces per man.

Strength of a naval brigade of 20 companies and 10 pieces of artillery:

1 Brigade commander.
Infantry—12 Field and staff officers.
40 Officers of companies.
1 Passed Assistant Surgeon.
1 Gunner.
2 Carpenters.
880 Rank and file.
40 Ammunition passers and carriers.
30 Pioneers.
25 Stretchermen.
10 Buglers.
8 Signalmen.
1 Master-at-arms, or
1 Ship's corporal.
3 Apothecaries.

One officer to command at place of landing of brigade called Beach-master, with three officers to command the divisions of boats at landing.

The master-at-arms or ship's corporal will have charge of all the mess outfit and one mess kettle for each company.

Artillery, 10 guns—4 Field and staff officers.
5 Officers of sections.
10 Junior officers.
1 Gunner.
230 Men.

Should no limbers be supplied, the crews would be reduced to 16 men for each piece of artillery, making a total of 160. In this event the other men, 7 in number, from each crew would be required to carry ammunition.

Pioneers will be armed and equipped as follows (Light Marching Order):

	Pounds.	Ounces.
Waist-belt, revolver, 40 cartridges	4	12
Haversack, two days' rations	5	15¾
Canteen, filled	4	4¼
Pot, spoon, pan, knife	1	4
Blanket, roll	4	11½
Tobacco		3?
Intrenching tools, bag of miscellaneous implements	13	
Total	34	2½

For Heavy Marching Order add 9 pounds 14¼ ounces.

Pickaxe, spade or shovel, crowbar, axe and saw should all be slung, if possible, over men's backs, also the bag of implements. Each armorer will carry an axe, weight 4 pounds, and a leather pouch or bag containing assembling and repairing tools and any spare parts for small arms—weight of bag 9 pounds.

Stretchermen will carry the following (Light Marching Order):

	Pounds.	Ounces.
Haversack, two days' rations	5	15¾
Canteen, filled	4	4¼
Pot, spoon, pan, knife	1	4
Blanket, roll	4	11½
Tobacco		3?
Outfit, supplies, etc	6 to 18	
Total	34	6½

For Heavy Marching Order add 9 pounds 4¼ ounces.

Buglers and *Signalmen:*

	Pounds.	Ounces.
Waist-belt, 20 cartridges.	4	4¼
Rifle	8	12
Haversack, two days' rations	5	15¾
Canteen, filled	4	4¼
Pot, spoon, pan, knife	1	4
Blanket, roll	4	11½
Tobacco		3?
*Signal kit	5	7
Total	34	13¾

For Heavy Marching Order add 11 pounds 8½ ounces.

* *Buglers* would carry bugle instead of signal kit. Buglers and signalmen are not armed with a bayonet.

MARINES.

The arms and ammunition of the marines should be the same as furnished to the seamen—the latest improved magazine gun. The arm now furnished to the marine corps is a pattern of bygone days, also the cartridge box. Why this well-trained corps should be so armed and equipped ought to be a question for immediate consideration. The marines should wear brown leggings, and their helmets should be brown or dark gray in color, for service in the field; white belts should be discarded for active service. The arms for the marines should have dark leather slings attached, and each man should carry 80 rounds of ammunition, except when landed for short service, when 100 rounds per man should be carried and the Mills web belt used.

WEIGHT OF ARTICLES CARRIED.

Light Marching Order.

	Pounds.	Ounces.
Rifle (Lee magazine, long barrel)	9	
Waist-belt, bayonet and scabbard	3	12½
40 cartridges	3	14
Haversack and two days' rations	5	15¾
Canteen, filled	4	4¼
Pot, spoon, pan, knife	1	4
Knapsack, containing one undershirt, soap, towel, comb, one pair stockings, blanket (wool)	8	10
Tobacco		3?
Total	36	15½

Heavy Marching Order.

	Pounds.	Ounces.
Rifle (Lee magazine, long barrel)	9	
Waist-belt, bayonet and scabbard	3	12½
One belt over left shoulder	1	
80 cartridges	7	12
Haversack and two days' rations	5	15¾
Canteen, filled	4	4¼
Pot, spoon, pan, knife	1	4
Knapsack	2	2½
Two blankets, wool and rubber, towel, soap, comb, one undershirt, one pair stockings, overcoat	14	8¾
Tobacco		3?
Total	49	14¾

Here I want to emphasize the importance of frequently landing the brigade fully equipped. When the brigade is encamped for drill and instruction, cooks will be sent from ships, and they will be under charge of the master-at-arms or the ship's corporal.

RATIONS.

The quality of the U. S. Navy regulation ration as now served out on ships is excellent. It frequently happens that there is not time to cook food on shipboard when the landing party is called away, and once on shore it may not be possible to go into camp at meal times. Some form of food like the Bologna sausage should therefore be added to the ration, and put up in packages for landing parties. The Navy ration as now put up is in too large packages which are not easily handled. When articles are served out to a small number of men there is great waste.

Articles like pork, beef, beans, sugar, rice, etc., should be put up in ¼ and ½ barrels. Other articles of the ration should be put up in small boxes that one man could handle easily, marked "Landing Party," and kept ready for issue. The greatest care must be given to the drinking water, and when the water is bad, weak cold tea or coffee should be carried in the canteen. At these times an extra allowance of tea or coffee should be served out to the brigade, the former being preferable in hot climates.

III.—TACTICS.

The conditions of modern warfare having changed the movements of troops in actual battle, we must eliminate from the infantry tactics everything that is not suited to these modern conditions. There is a great cry at the present time for an immediate change in our tactics. It would appear that there are not so many changes demanded by the modern conditions of war, but that a confusion of terms has arisen in the application of the words *tactics* and *science*. Infantry tacticians seem to be of one accord that extended formations are necessary, and that night attacks will be more common, if we would provide against the destructive effects of an enemy's magazine rifles. Instead of masses marching in close formation, a loose order of fighting will have to be adopted, the aim being individual action, with all working to gain a common end. The axioms of the day are that "troops once engaged they cannot be relieved, and they must always be rallied to the front." I will not attempt to go into the much-vexed question of the hour, how to close with your enemy without being so badly cut to pieces or so depleted by losses that any attempts to charge him would be idiotic; the greatest military writers of the day have failed to solve this question, and it is one that pertains more to the science of war. The first line of battle being formed by the skirmishers pushing forward, the supports would be gradually absorbed by this first line, when the main body of infantry and artillery would advance.

It is questionable if much is gained, except when advancing on a strongly entrenched position, by what has been so frequently advocated in the past few years, advancing by rushes. Running heats the blood and makes the nerves unsteady; firing under these conditions is a waste of ammunition and encourages the enemy. When advancing on the enemy, good marksmanship is sought after, and with running the conditions are unfavorable.

At Tel-el-Kebir the English Royal Marines advanced by rushes, and, as a result, were beaten into the enemy's works by another battalion that never stopped after once taking up the rapid advance, carrying everything with them.* It is impossible to lay down a positive rule; we must be governed by circumstances and the capabilities of the enemy.

The sailor possesses some of the highest of the qualities required by the tactics of the present day, and we should train him to develop these qualities to the utmost degree. Stiffness and regularity of movement are in direct contrast with his every-day life, and only that part of the manual of arms which would be required on the field of battle should be taught to him. Of what use is "Present arms," "Reverse arms," "Rest on arms," etc.? It is a waste of valuable time to teach these movements to the seaman. The "Position of the soldier" and "Setting up" drill, found in Upton's Tactics—and this would probably apply to any tactics—should not be imposed upon the seaman. It is simply absurd to talk to the sailor about "the little finger behind the seam of the trousers"; too great precision and uniformity of movement should not be required. When not marching, pieces should be invariably at an "order," and any order for a forward movement would be the signal to bring them to a "carry." All facings should be done with pieces at an "order," and thus avoid tiring the men with their constant weight. In moving to the attack, pieces should be brought to the position of "Arms port," a convenient position to take the "Ready" from, the piece and arms at the same time affording a considerable protection to the body. The position of the piece at "Arms port," in company or platoon front for clearing streets and forcing back a mob, is in common use; but it is a mistaken idea to use gentle measures when dealing with mobs. Nothing takes the nerve out of the proverbially cowardly mob so quick as the bayonet. The "Level trail" with the arms hanging naturally, so much used in England, is a very convenient way to carry the rifle while marching in column. Marching in line, the rear rank will open out one pace.

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* Gen. Sir Edw. B. Hamley, in the *Nineteenth Century*.

It is almost impossible for a sailor to learn so many bugle calls in the short time devoted to infantry drill; even the officers do not acquire them. "Advance," "Retreat," "Halt," "Fire," "Load," "Cease firing," "Assemble," "Charge," are all that are required; and they should be sounded frequently, that the men may be made accustomed to them. Ships' boats might be named "Advance," "Retreat," etc., and called away by bugle with these names. Should a boat be wanted while at general quarters, the boatswain's whistle would be used and the boat called away by name.

I am an advocate of the whistle for company officers. On the skirmish line it would be indispensable; and as the calls are very easily acquired and familiar to the sailor, the whistle or boatswain's call would serve the purpose better than the bugle. All pieces should have dark leather slings and the men should be accustomed to their use when firing.

In Upton's Tactics we should do away in the manual with "Present arms," "Secure arms," "Rest on arms," "Reverse arms," and "Support arms." "Carry arms" should take the place of "Present arms" in saluting. The heavy infantry "support" should be used, as it is adapted to the bolt-gun, which has no projecting hammer. At the order "Halt," when marching under arms, pieces should be brought to an "order arms" without further delay.

The strict drill of the soldier has for its object the disciplining of the men, that implicit obedience to orders may at all times be expected and obtained. The sailor having therefore been educated up to this implicit obedience on that most excellent parade-ground, the quarterdeck, why devote further time to his discipline at the risk of breaking his spirit of independence, which is now so much sought after in the new school of fighting men demanded by the open fighting formation. Better to teach men to be marksmen with no instruction in tactics, than to have a dress-parade sailor with no idea how to load and fire his piece, not to mention sighting at an object 500 yards away.

I have attempted to enumerate some of the changes in the manual of arms that would benefit the brigade under our present system of training. The adoption by the Navy of the U. S. Army Tactics, of whatever system it may be, will always be a necessary consequence; but the manual for the Navy must be suited to the arm, as well as to the sailor; the tactics for both Army and Navy being the same. Slight changes in the manual as at present given us in Upton's Tactics could be made with much good resulting therefrom; but these changes should be closely followed by every ship in the service, all adhering to the same drill. Marching in company front and the attempt to imitate the solid wall may receive the applause of the public; but to gain such results, what a sacrifice of valuable time that should have been devoted first to the loadings and firings, and second to the skirmish drill! Constant drilling of the company with small intervals between files, sighting and firing the piece, with the expenditure of plenty of small arm ammunition at target practice, is a necessity that must be apparent to all.

In deploying the modern fighting line, Upton's Tactics under the head of "To deploy the battalion as skirmishers by numbers," the battalion being in line, commends itself. To deploy from column, a certain number (specified) of companies would move to the right front into line, and a certain number (specified) to the left front into line. The deployment of infantry on the march from column should of course be carried out before the fire of the enemy's artillery has begun to tell on the ranks.

Under the present system of musketry instruction, the Navy has no field-firing to speak of, particularly when men are attached to sea-going ships. The time has come for an immediate change, not only that the naval brigade may be efficient, but that riflemen stationed in the tops and about ships' decks in battle may fire with accuracy. In this particular we could take pattern from the Army and have more rifle-range firing. Seamen are supplied with as good fire-arms as science can produce; but however excellent these arms may be, in the hands of unskilled marksmen no effective work can be performed. The men should be taught at the different Receiving Ships, both in rifle and machine gun firing.

If the time devoted to cleaning bright-work on shipboard were taken up in teaching the crew aiming drill and file-firing exercise, we would have more efficient marksmen in the service, and necessarily more effective crews. Bright-work should be painted out, covered with canvas, or anything to get rid of it in a ship—its cost is not a subject for this paper.

Any unseemly haste to rush through the small-arm target practice in cruising ships is absolutely indefensible. And though we are much in want of a system of rifle range practice with small arms, still it lies in the power of a commander of a fleet to send his battalions ashore to compete for prizes and medals at the range when he assembles the vessels for their annual drills and inspections. At these contests, individual competition should be paramount and the marksmen be encouraged in their work.

In seagoing ships the officer of the deck in the afternoon watch should be relieved by a junior, when he would drill his company in the loadings and firings with the dummy cartridges. Cartridge boxes or belts should be filled and several rounds fired, to ascertain just what the men are capable of doing. On an examination of the pieces and the boxes or belts after each ten or fifteen rounds fired, and before the dummies are gathered from the deck by the quarter-gunner, the effectiveness of the firing drill would be known. This would not only accustom the men to be expert in the loadings and firings, but familiarize them with the breech mechanism of the piece. The rough usage to which the mechanism of all breech-loading firearms is subjected in service on shore calls for special attention to its care if the arms are to be kept in a serviceable condition. Arms and ammunition should be examined very frequently. Officers and men should be made familiar with all the parts of the magazine guns, and understand which parts are most likely to be rendered unserviceable. The men should be thoroughly taught the working of the breech mechanism, and when landed in the brigade, should frequently examine the gun and ammunition to see if the parts of the former are in good working order and that the ammunition is clean and fit for use. On fitting out an expedition, great pains should be taken to examine the ammunition, to see that it will fit the arms for which it is supplied. It cannot be too strongly impressed on the minds of drill officers that all drills not fitting the seaman for battle should be abolished, the manual should be the simplest possible and adapted to the requirements of the service.

When we realize it is claimed that the modern arm in the hands of fairly drilled men requires the discharge from it of nearly twice the mean weight of a man in lead before it effects his death, we cannot be too careful in our firing instructions. In firing, if any control is to be obtained over a command, the order "five rounds" or "ten rounds rapid fire" should be used. Under the head of fire discipline, I quote from General Von Kraft of the German army, who is authority on this important subject: "I have often remarked how much fire discipline is weakened in action when the element of danger makes itself sensible. Troops imperfectly trained do not aim, they do not even fire, they only let off their pieces. . . . . . But how much more trouble is required before we can train the infantry soldier to pay attention to orders and signals during all the excitement of battle, to observe the object to be aimed at, the sight and mode of firing to be used, and to cease firing when the specified number of rounds has been expended. . . . . But if, as we have remarked, soldiers must already attain to a certain pitch of fire discipline before you can be sure of getting them even to bring their rifles to the shoulder in battle, how much greater pains must be taken before you can get them to take aim. . . . . When firing once begins men get easily out of hand unless restrained by an iron discipline. . . . . It is but human nature that a soldier should derive some comfort from the noise made by his own gun when it goes off. The more raw the soldier the more will he be inclined to 'shoot himself into courage.' . . . . Taking such facts into consideration, we cannot help doubting whether the order 'Five rounds rapid fire' when given at close quarters, say 300 yards, will be attended to."

The Elementary Light Artillery Tactics as now taught at the Naval School, Annapolis, and generally throughout the service, appear to be all that is desired. The men should not carry bayonets and cutlasses, and the drill should be completed for the gun with limber, and the crew increased to 23 men, if we would guard against the new dangers to which artillery is exposed by the development of rifle fire and the difficulties encountered in the supply of ammunition. In the *Elementary Tactics* we must confine ourselves to one system of drills—and there are many good systems—for all the service, eliminating everything not tending to efficiency on the field of battle. The modern conditions of war demand that for *Grand Tactics* the movements of guns in battle must be at a "double." This fact is supported by the field movements in action of European artillery, which require the guns to be moved by horses at a run. By doing away with cutlasses and bayonets, the former being liable to get between the men's legs, not to speak of the extra weight and general uselessness of both, the guns' crews are as near flying-light as it is possible to make them, and at the same time they retain their efficiency, care being taken not to bring guns into action without infantry supports *in advance.*

Wishing to emphasize what has been said before, I would again call attention to the necessity of simple and effective drills in both the artillery and infantry, and the avoidance of *ceremonies* that belong to the parade-soldier. As little time as possible should be devoted to dress parades.

THE DISEMBARKATION AND LANDING OF THE NAVAL BRIGADE.

In the disembarkation of the brigade great care and attention should be given to the boat organization. Each company of infantry (seamen) should land in the two ships' boats belonging to the division of which the company forms a part; being at all times accustomed to go in these boats, there will be no confusion. The larger boat will be in charge of the captain of the company—the lieutenant of the division—a junior officer of the division being in charge of the smaller boat. These two boats must always keep together, the larger one being on the right, and in forming the "order before landing," must take the same relative position in the line as the company holds in the brigade when formed on the beach.

The rifle howitzers and machine guns will go in the heavy boats. Three or four hammocks placed in the bows of boats, about the pedestal for the revolving cannon, would be a great protection to the crews of the guns in action. The marines will land in separate boats pulled by sailors, the latter being detailed from companies belonging to the reserve; though, with a system of boat drill in this corps, the marines could in a short time manage their own boats. A company of marines with their officers should be assigned to two boats, the boats keeping together.

The boat divisions in the "order before landing" will be commanded by the battalion commanders, each battalion forming one division of boats. The senior officer's boat of each division should have a mast, from which signals should be made and repeated; and should also carry signal books, spyglass, and a box containing medical supplies and outfit. Each boat must be provided with a signal book and answering pennant.

Each division of boats should have a distinguishing flag, and each boat should be numbered in the "order before landing" from right to left consecutively, 1, 2, 3, etc., commencing on the right of the skirmishing boats down the line, then to the right of the main body down that line, and the same way with the reserve and hospital boats. The artillery boats should be lettered from right to left, A, B, C, etc., to distinguish them from the other boats. Boats should have their numbers and letters painted on canvas, large size, and nailed to the stern and both bows; if possible, the numbers of the same color as the divisional flags. Each boat must carry an anchor and chain or rope, and in landing the boats must anchor by the stern, going ashore bows first.

It adds considerably to the comfort of a landing party if they can get on shore dry-shod, and to do this gang-boards could be carried slung over the gunwales of the boats underneath the oars; spare pieces of lumber found on shipboard and the carpenter's bench could be utilized for this purpose. Each boat should carry a bucket for bailing, materials for stopping shot holes, and a breaker of water. Intrenching tools, rope ladders, etc., should also be distributed among boats. Boats will carry their own ammunition. Spare ammunition and extra belts for the infantry will be carried in boxes—it might be more convenient to carry the latter in canvas bags. Empty powder tanks carried in boats make good magazines for the storage of ammunition when it is put up in canvas bags. The amount of ammunition will depend upon the nature of the service.

Before undertaking an expedition, proper means for the transportation of ammunition supplies, camp equipage, etc., should be provided by the quartermaster. Improvised means of transportation with carts made on shipboard should be the last resort, for they seldom answer the purpose required of them. Life rafts, or temporary rafts, are very convenient for landing, and a great assistance in getting ammunition and supplies on shore. No pains should be spared to land men and outfit dry.

If transportation is to be obtained and a lengthened stay on shore is to be made in encampment, boats should carry stoves, one for every two companies of infantry or four companies of artillery; also two scouse kettles and four mess kettles, sails and spars for tents, provisions and water.

It must be borne in mind that the nature of the service to be performed governs the preparations of the naval brigade. The more distant the service from the base of supplies, and the longer the stay, the more the brigade must be governed in its movements by the rules laid down for a brigade of infantry; and those who would study this interesting subject are referred to that admirable work, "The Soldier's Pocket-Book," by Lieutenant General Sir G. J. Wolseley.

The light-draft vessels should anchor near beach to protect the landing, and also act as a base for supplies. They should keep as near to landing party during the time the force is on shore as the depth of water will permit, one vessel being used for the ordnance boat and another for provisions and hospital. Several of the vessels that are to cover landing should be provided with electric search lights. Should the landing be made in the night time it would be well to have three covering vessels with search lights, one on either flank and the other behind the centre of the "order before landing." These vessels would keep out of the effective range of shore batteries, or move about, altering their range and position frequently. They would light up the beach with their electric lights, and the landing force would approach the shore in the dark zones between the lights, so as not to be seen by the enemy. The brigade once landed, the search lights would be used to light up the country in the direction of the enemy, and good lookouts stationed aloft would report any suspicious movements, when signal would be made to the force on shore.

In forming the "order before landing" (see Plate I.) each boat should take the station assigned it in the organization; the presumption is that every officer has been made acquainted with all the details of the organization both before and after landing. When the distance to the shore is great, boats should be towed to a convenient place from the landing and out of range. The boats mounting the heavier guns of the artillery will be on the extreme flanks of the "order before landing," and next to them the light guns; all the artillery boats in echelon formation, with the main body of the infantry between. Two boats' length in advance of the centre of the main body of infantry, the skirmishers in light fast boats should be massed, with a few machine guns on the flanks, if desired.

The skirmishers, generally speaking, would be taken from the companies of marines. The reserve will be in the third line in rear of main body, and it would consist of about one-sixth of whole force; they are not to land until main body is well established on shore and has moved back from the beach. The hospital boats will be three boats' lengths in rear of centre of main body of infantry. These boats will be pulled by the stretchermen, and they should be light single banked boats, containing medical officers and outfit, flying the hospital flag. Hospital boats will land with the main body of infantry, under charge of the medical officers and under orders of the chief of staff. The first line—skirmishers—should be two boats' lengths apart. The second line, main body, two boats' lengths in rear of skirmishers and one boat's length apart. The third line, reserve, three boats' lengths in rear of main body and one boat's length apart. The hospital boats in rear of centre of main body three boats' lengths, and in pairs one boat's length apart. If there should be opposition to the landing of the brigade, the beach would be cleared by the covering vessels and artillery, and in the event of a heavy fire being directed on the boats it may be necessary to open out the "order before landing" and land on a more extended front. Signal being made by the commander of the brigade, the skirmishers will pull in and land, deploying as soon as landed, taking advantage of such shelter as the ground may offer, after which, signal would be made for main body to land with light machine guns, followed by rest of artillery. The main body having advanced from the beach, the reserve would land.

If it be not the intention that the brigade should remain on shore, any length of time, the landing once effected, to the larger boats with artillery four boat-keepers will be allowed, and to the smaller ones two boat-keepers. The boat-keepers will have their boats out to their anchors after landing, turning the boats' bows out with stern lines to the beach, one man remaining in each boat to veer in when ordered. The boat-keepers are in excess of the number of men allowed to each company. All the artillery boats should be prepared to mount and fight their guns in the sterns of boats, though this might not be possible with the steam launches.

Each division of boats should be careful to keep together in their assigned places with the division flag displayed, one of the boats in each division displaying the flag from its mast. Always being prepared to embark under fire of an enemy, each division of boats will be under charge of an officer, with an officer selected to command on the beach, styled beach-master. The beach-master will have charge of all the boats and force left at the beach, and he will see that the boats are in readiness to embark all the brigade at a moment's notice. He will keep up communication by signal or otherwise with the covering vessels, and if possible with the main force. Such precautions as seizing any commanding position and throwing up breastworks would be performed by the beach-master. To prevent surprise, he should throw out a picket, and when circumstances require it, a squad of petty officers should be added to his force.

The preparations for embarking having been carefully attended to, on the approach of the brigade the boats will drop in near the beach. If the brigade is pursued by the enemy, entrenchments thrown up by the beach party will be manned, and a few pieces of artillery will be left with the infantry to keep back the enemy. While the main portion of the brigade is embarking, the covering vessels and artillery will keep up a cross fire on the beach until all the force has embarked, the skirmishers being the last to leave the beach.

In the disembarkation, many points come under consideration which require much thought and experience; such as the amount of opposition to be met with from the enemy on landing, the nature of the country, length and character of beach, depth of water and state of the tide. A low, broad, convex beach affords the safest place for the brigade to land, if opposition is to be met with from the enemy. If possible to obtain a chart of the landing place, no disembarkation should be made without one. This chart should show depth of water, character of bottom, and time of high and low water. Each commanding officer of a division or battalion and the beach-master should have a copy of this chart, with the *state of the tide* marked on it for the *time* of landing. It should also show the "order before landing" of the boats and the position of the covering vessels.

Marines.—The tactics of the marine corps being the tactics adopted for the United States army, the marines would assemble with the seamen in the brigade, with no confusion to the latter. The manual of the corps should be the same as that taught to the seamen in all their drills and service with the naval brigade; uniformity in the brigade must be sought after and obtained, and the smaller factor must give way.

All the officers and men of the marine corps should be instructed in the handling of machine guns both afloat and ashore. At the present time the marines suffer for want of experience at the rifle range. They are not landed as often as they should be for instruction in target practice and open-order fighting. If capable of pulling their own boats, they would be independent in their transportation to and from ships.

Marches.—When no opposition has been made to the landing of the naval brigade, a reconnoissance must be made to ascertain the whereabouts of the enemy, the nature of the reconnoissance depending on the kind of information desired.

If proper care has been taken in fitting out the expedition, charts of the country will have been supplied, with cities, towns, villages, direction of roads, streams, etc., and any high land marked on them, also a weather map and almanac to date. These charts would, if it were possible, have been prepared by the Bureau of Intelligence at Washington, otherwise by the commander of the expedition. Some idea of the country, its inhabitants, the wet and dry seasons, food, animals, etc., must first be obtained before an advance is made into the interior. The commander of the expedition will decide how the march is to be taken up, bearing in mind that a large force divided into two columns will march faster than in single column and with less fatigue to the men. It is also more easily deployed into line of battle; the maxim is, "separate for marching, unite for battle." In the formation of the order of march, guns and ammunition should be so placed in the column or columns that, upon falling in with the enemy, they would be in such position where most likely to be wanted. The time required to come up with the enemy would determine the formation of the order of march. Assuming that you are within striking distance of the enemy, and that a fight with him may take place at any time, care must be taken that each column has an advance guard and is in constant readiness for battle, and that the columns are strong enough to take care of themselves, and are within supporting distance. Artillery must never march alone, nor be left unsupported by infantry. Signalmen must accompany the advance guard. A flank patrol would also be necessary, and communication must be kept up between it and the main column. See Plate II., Figs. 1, 2.

At night, the advance guard, unexpectedly falling in with the enemy, must attack him immediately; there is nothing else left to do if the main column is to gain time for preparation. If necessary, the men and officers must sacrifice their lives, for upon the stand that the advance guard makes, the fate of the main column may depend. If forced back, under no circumstances must they retreat on the main column, but must retire on either side, unmasking its front.

Marches in retreat.—In retreat, the order of march is the reverse of that in advance, the rear guard being much stronger, and from one-fourth to one-third of the whole force, depending upon circumstances.

Street fighting.—In the occupation of towns and cities, street fighting will always play a prominent part in the work required of the naval brigade, and too much time and attention cannot be devoted to its study. A map of the place to be occupied, showing principal streets, squares and public buildings, should be obtained. Having determined upon a plan of operation, move in two or three columns toward the central portion of the place, and occupy a prominent square where the people are in the habit of congregating. Columns should keep up lateral communication with each other, and a body of pioneers should precede each, supplied with gun-cotton or other portable explosive for blowing down doors, buildings and barricades. A column meeting with barricades should not attempt to carry them in front if time will permit of their being turned by working to their rear through adjoining buildings. Advantage should be taken of any flat-roofed houses in working a column through a city. The advancing columns should be closely followed by the supports; surrounded by burning and falling buildings, with firing in every direction, men become bewildered and hesitating if they are not well supported.

In the advance, do not leave burning buildings in your rear if they threaten to cut off your line of retreat. Your forces once established, look to the water supply, and seize any fire engines. The engines should be overhauled and put in order by the force of firemen from the pioneers that accompany the expedition.

If you are fighting to obtain possession of a city, seize all food supplies; all the inhabitants that remain in the city should be enrolled and set to work, and everybody put on the same allowance of food. Arrest any one found on the streets between sunset and sunrise. Establish a signal station on highest building near to headquarters, or at headquarters if within signal distance of fleet. No officer or man should be allowed on the streets without arms or equipments. Keep open your line of retreat, but do not forget that a small force of determined men can keep at bay, in a well-barricaded building, many times their number; in fact, do not allow yourself to be burnt out and you can stay until relief comes, provided your food holds out. Remember the history of the Pittsburg labor riots of 1877 and the cooped-up militia in the engine-house of the Pennsylvania Railroad.*

Should your object be to quell a riot or insurrection, establish your headquarters at the town or city hall; place yourself in communication with the civil authorities; organize a police force, or lend all aid in your power to the regular force of the place. Barricade and be prepared to defend building or buildings in which your forces are located; two buildings commanding each other are better than one. Never, under any circumstances, permit more than two-thirds of your force to be absent from headquarters on patrol or other duty. If you take any prisoners, do not confine them in your headquarters. Never permit any strangers to inspect your preparations for defense. Arrest any one found looting; impress upon the minds of your officers and men that no property of any kind must be taken; everything that is found must be turned in to the quartermaster. There is nothing so demoralizing to a naval force as to allow men to appropriate articles; the very severest punishment must be inflicted for looting, if any discipline is to be maintained. Sentries should be placed over all buildings near to headquarters where liquors are stored; and above all things, never locate a command in any building without first making a careful inspection to ascertain if there are any spirituous liquors stored therein.

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* "The United Service," Vol. I., Pittsburg Riots.

Bivouac.—Plate III. illustrates the general principles of bivouacing with outposts thrown out in the direction of the enemy; when necessary, the flanks and rear would also be protected. The general rule is that about one-sixth of the whole force should be employed on outpost work—the most important duty devolving upon the brigade.

As it takes a very considerable time to break out of tents and strike them, they would not be used in the presence of an enemy or when anticipating an attack.

The German system of outposts is probably the best and most simple. Some 400 paces to the front of the first line, double sentries are placed—this is the only distance given; the other distances, the reserve from the first line, also from main column, are at the option of the commanding officer of the outposts, he being governed by the "general state of affairs and the time the main body requires to get ready for action." In locating the outposts it would be well to remember that one officer should command on each front of the camp; by this means any confusion in the location of the outposts is avoided. The officer commanding the outpost should belong to the command to which the detail for outpost duty also belongs.

Camping (Encampment, Plate IV.).—In selecting a site for laying out a camp, when not in the presence of an enemy, we must consider sanitary conditions, nature of the ground with regard to the comfort of the men, and the supply of wood and water. An abundance of fire-wood and plenty of fresh water near at hand make any locality a desirable one. The form of the camp will generally be suited to the ground, both artillery and infantry camping on ground best suited to them. In going into camp, each battalion of the brigade would encamp in column of divisions, the tents of each division facing each other, being arranged in two lines and trenched. As far as practicable a general alignment should be preserved, though regularity should not be sought after over more important considerations. The commanding officer of the brigade, also the battalion commanders, should have distinguishing flags on flagstaffs to indicate their headquarters.

In encampment the routine is established by the commander of the brigade, due regard being given to the season of the year.

Camp routine, when brigade is landed for drill and instruction:

h. m.
A. M.—4.00—Call cooks.
5.00—Call bugler of guard.
5.10—Assembly of buglers.
5.15—Bugles and drum march through camp.
5.25—Reveille, assembly, coffee.
6.30—Breakfast.
7.15—Sick call, fatigue call, police camp.
8.00—First sergeant's call, morning reports.
8.30—Drill call.
11.00—Recall from drill.
11.30—Assembly, guard mounting.
12.00—Dinner.
P. M.—1.00—Drill call.
2.00—Serve out provisions.
3.00—Recall from drill.
5.00—Battalions form.
5.15—Brigade forms for dress parade.
5.45—Supper, sundown retreat, orders, details for day following.
8.45—Assembly of buglers.
8.50—Bugles and drum march through camp.
9.00—Tattoo, assembly.
9.15—Bugles, lights out.

To Arms is the signal of alarm, when the brigade will turn out under arms. The *general* is the signal to break camp, preparatory to marching.

Base.—The base of operations of the naval brigade is an important consideration that presents itself to us. Under most circumstances the fleet would be the base, but in operating on rivers and streams, some of the fighting vessels of the fleet with a despatch boat should accompany the boats to be used as a base, if the depth of water will allow. Should the water be shallow, steam launches, armed with Hotchkiss revolving cannon and the single barrel Hotchkiss, with temporary protection for their crews, should accompany the landing force. These launches would not land, and should have large crews, every man in the boat being armed with the magazine rifle, which should be kept at hand ready for use when occasion demanded. Vessels and steam launches accompanying the brigade should, if possible, keep up communication with the force and be prepared to furnish anything necessity required. Accompanying vessels should have large supplies of provisions, ammunition and medical outfit.

In conclusion, the essayist has endeavored to avoid the common fault of the day, when treating of a professional subject, of dealing in generalities. In making suggestions he has attempted to name something better, and solve, with useful details, where he has condemned. To condemn the practices of the service without working out and presenting in detailed form something more worthy of trial, is to remain at a standstill and fail of the purpose sought.

There is nothing in this essay that the writer claims as new and untried; were he to do so, it might detract from its value. Having consulted every work within his reach published on the subject of Naval Brigades, and they are not many, he has summarized and placed the information obtained, with his own experience added, in such shape that he hopes it may supply a long and growing want, benefit the service at large, and be of *practical use* to the brigade commander. Taking hold of a practical subject, the essayist has attempted a practical solution, avoiding any digressions to new-hatched thoughts which would add length to the essay with no beneficial results. Being a great believer in the naval brigade and its valuable work, he would at the same time jealously guard the seaman from the machinations of the infantry-crank and toy-soldier, always keeping in mind the *materia circa quam* of a navy.

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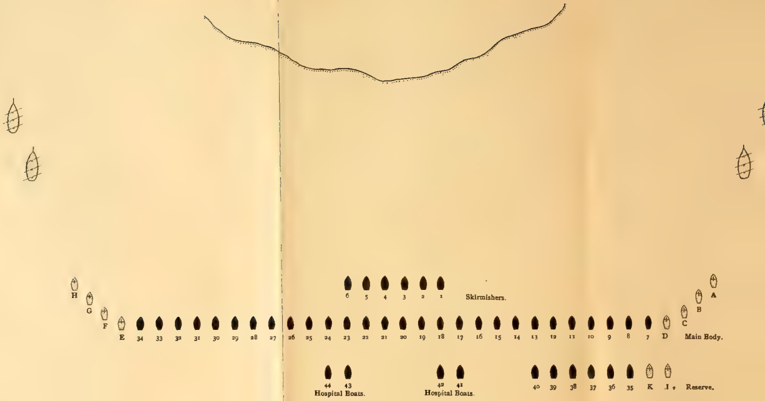
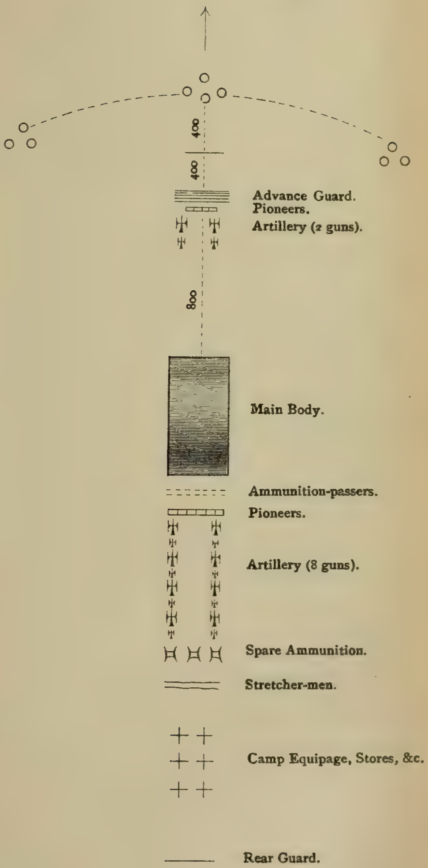

6 5 4 3 2 1 Skirmishers.
H G F E 34 33 32 31 30 29 28 27 26 25 24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 D C B A Main Body.
44 43 Hospital Boats.
42 41 Hospital Boats.
40 39 38 37 36 35 K I Reserve.

PLATE I.—ORDER BEFORE LANDING.

Skirmishers, two boats' length apart.
Main body, Reserve and Hospital boats, one boat's length.
Skirmishers' boats from Main body, two boats' length.

Main body from Reserve, three boats' length.
Artillery on flanks of Main body, in échelon.
Reserve, about $\frac{1}{3}$ of whole force.

Fig. 2.



ORDER OF MARCH.

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Fig. 1.

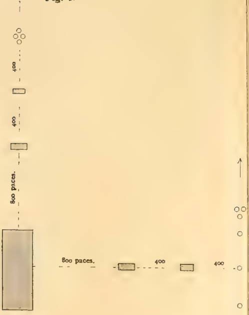


Fig. 2.

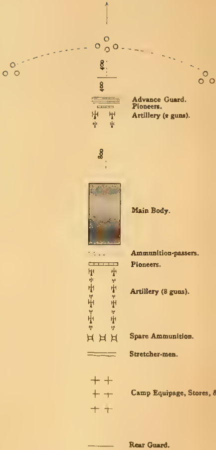
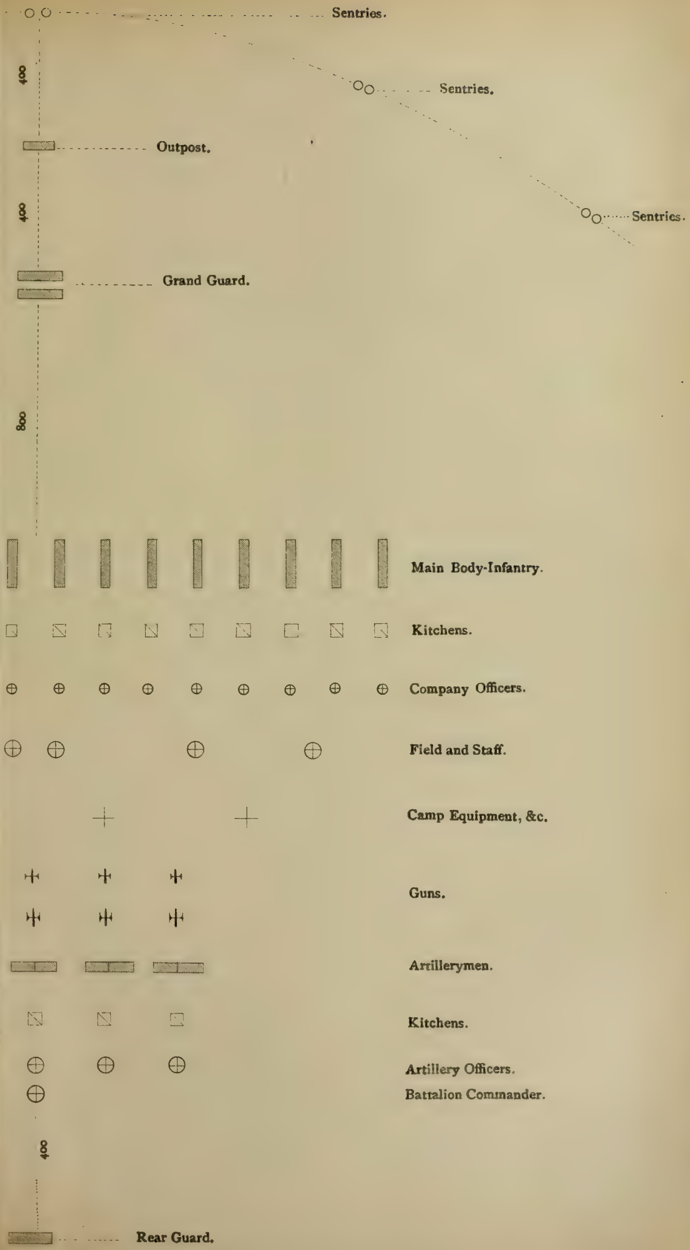


PLATE II.—ORDER OF MARCH.

Distances are in paces.


Sentries.
Sentries.
400
Outpost.
400
Sentries.
Grand Guard.
800
Main Body-Infantry.
Kitchens.
Company Officers.
Field and Staff.
Camp Equipment, &c.
Guns.
Artillerymen.
Kitchens.
Artillery Officers.
Battalion Commander.
400
Rear Guard.

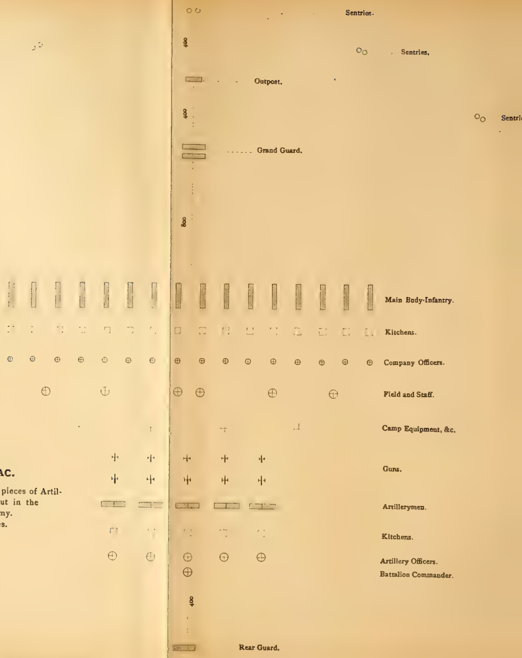
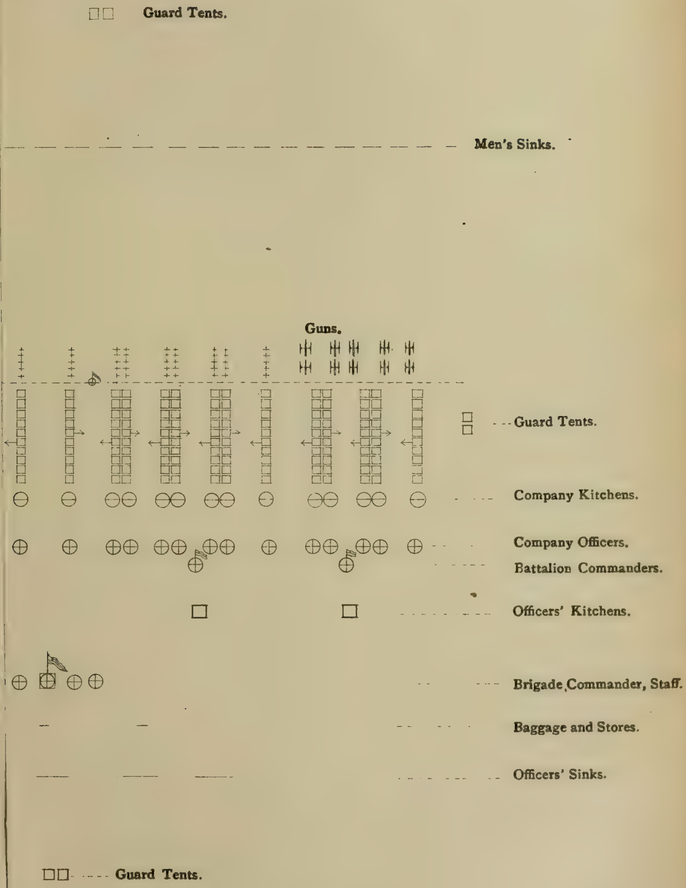


Plate III.—**BIVOUAC.**

Twenty Companies of Infantry, 10 pieces of Artillery, with outpost thrown out in the direction of the enemy.
Distances are in paces.


Guard Tents.
Men's Sinks.
Guns.
Guard Tents.
Company Kitchens.
Company Officers.
Battalion Commanders.
Officers' Kitchens.
Brigade Commander, Staff.
Baggage and Stores.
Officers' Sinks.
Guard Tents.

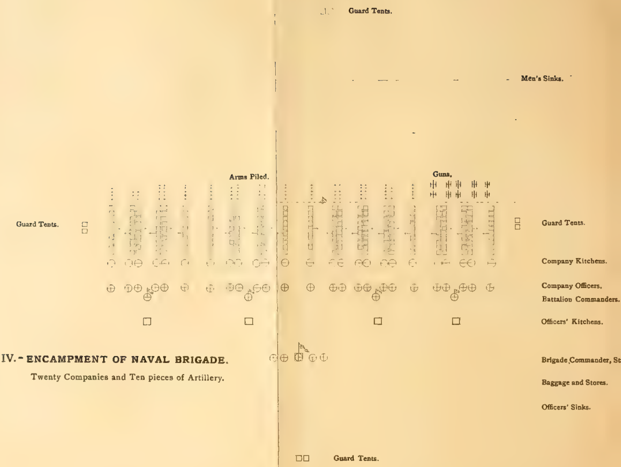


PLATE IV.—ENCAMPMENT OF NAVAL BRIGADE.

Twenty Companies and Ten pieces of Artillery.

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U. S. NAVAL INSTITUTE, NEWPORT BRANCH.

APRIL 27, 1887.

CAPTAIN A. R. YATES, U. S. N., in the Chair.

TRAINING OF ENLISTED MEN OF THE ENGINEER'S FORCE.

By PASSED-ASSISTANT ENGINEER W. M. PARKS, U. S. N.

The engine department of a modern war vessel may be compared to a machine shop. This comparison holds as well when the engines are in motion as when repairs are making to the main engines, or to the many auxiliary engines used. To get the best results in either case, there should be a force of trained workmen working under competent supervision. There should be a superintendent; there should be foremen or leading men; there should be journeymen, and there should be a certain number of unskilled laborers. In this scheme we may regard the engineer officer in charge as the superintendent. The machinists, men who have served regular apprenticeships, we may regard as the foremen. Following the natural order, the firemen or stokers should be the journeymen, while the coal-heavers form the laborer class.

Unfortunately for us, the firemen—men who should be the journeymen according to our scheme, men who form the majority of the engineer's force—are, as a rule, unskilled in the use of tools and untrained in the rudiments of the art of stoking. The object of this paper is to make a plea for the training of these men; to insist that they shall serve a short apprenticeship, at least, before they are sent to our ships to attempt the work of journeymen. What would be the result if, in a machine shop, only laborers and apprentices were employed? In our war vessels the engineer's force is largely made up of laborers and apprentices. The small number of skilled men, the machinists, can have but little effect upon the mass of the unskilled.

In these days, when it is necessary to have trained men for every one of the various special duties that are found on a war vessel, the fact seems incredible that we neglect to train men for the important duty of properly burning the fuel that is to give power to so many engines. We may continue to design engines that are to be, in theory, the most economical ones possible; but unless we begin now to train the men who handle the shovel, failure will follow every attempt to get, in practice, that power per square foot of grate area that theoretical calculation and the experience of others lead us to believe should be obtained. In our old-fashioned ships, now happily disappearing, the boilers and engines, without much regard to weight or space occupied, are so proportioned that the required horse-power is easily obtained, no matter how wastefully the fuel is burned. In these old ships natural draught is the rule, and from four to six I. H.-P. is required from each square foot of grate surface. Now, however, we see the beginning of a new Navy, with modern machinery, high pressures of steam, forced draught, and the never-settled problem of obtaining the greatest I. H.-P. per square foot of grate. All these changed conditions demand changes in methods.

Look at a few examples showing the need of a trained fire-room force. The boilers and engines of the U. S. S. Atlanta are certainly large enough and heavy enough to furnish 3500 I. H.-P. Her machinery is of an approved and well-tried type, and the method of getting the forced draught is one that has been successfully tried, and yet we have not succeeded in getting the very moderate number of nine I. H.-P. per square foot of grate that the contract requires of that machinery. I say "very moderate number," because, to mention a few examples, the machinery of the English ironclad Colossus has developed eleven and one-half I. H.-P. per square foot of grate area; that of the Impérieuse, fifteen; that of the Howe and of the Satellite, each over sixteen; while twenty I. H.-P. per square foot of grate is expected from the machinery of the Nile. All of these vessels, of course, use forced draught. Surely no one will deny that we need trained men for the fire room, men who will be able to get the greatest power possible out of each pound of coal burned. Remember that we have not yet obtained nine I. H.-P. per square foot of grate with the Atlanta's machinery, and have barely obtained eight and one-third I. H.-P. per square foot of grate with the Dolphin's machinery. These are moderate requirements. From the machinery of the Baltimore we must get double or nearly double the foregoing proportions, if the required power is to be obtained. A trained dockyard force will get this power, but with our present force of untrained stokers that power will never again be approached. We certainly need a trained dockyard force for power trials; but we need, and pressingly need, a system of training for all the enlisted men of the engineer's force. Much of the plan that I shall propose is not new.

Without going into details, the central idea of my scheme is that all enlisted men of the engineer's force shall have as thorough a training as may be possible in stoking all kinds of coal used in the furnaces of marine boilers, under the conditions of forced and of natural draught, and shall be taught to do the ordinary work of the engine and fire room, under competent supervision; this instruction to be given before the man is sent to a cruising ship. We should thus have in time a body of trained workmen, men who would work intelligently, whether stoking or overhauling machinery, and the engineer officer in charge would be relieved from the necessity of pointing out the exact spot in a furnace where each shovelful of coal should go, or of consuming valuable time to show an inexperienced man how to hold a wrench.

To begin, the apprentice system should apply to the engineer's force. A certain proportion of the boys enlisted on the Minnesota should be kept there to receive instruction by engineer officers detailed for that purpose. The boys should be taught how to handle tools, how to pack stuffing-boxes, to do rough blacksmithing, and to take down and to put together parts of machinery. They should be made familiar with machinery; and, above all, they should be taught the almost lost art, in our Navy, of the stoker. When we get steam training ships, as now seems probable we shall do, the instruction of the engineer apprentices should be continued by their instructors. Practical instruction in stoking with forced draught would be possible. In time we should be able to get all our trained workmen for the two great branches of the service from the same source—the training squadron.

As an extension of this system of training, such of the boys as show marked ability should be sent to the machine shop of some navy yard and required to serve a regular apprenticeship. From this class the machinists of the Navy should be recruited. While serving their apprenticeship in the machine shop, these boys would still be under the instruction of an engineer officer. They could live on the receiving ship at that yard. On the training ships a system of instruction should be established having rewards for the least coal used to obtain required results, or rewards for taking down and putting up machinery in the least time and in the best manner.

For our present most pressing needs, every receiving ship should be a training school. These schools are ready for the pupils, for on nearly all of them there is machinery, antiquated no doubt, but yet affording a field for instruction in handling the ordinary tools used on shipboard, and for practical lessons in stoking. There should be two engineer officers on every receiving ship designated as a recruiting station for firemen. There should be two receiving ships so designated, one at Norfolk and the other at Boston. The engineer officers detailed as recruiting officers and as instructors should be responsible for the proper training of the men enlisted by them. All men presenting themselves for enlistment as firemen should, after the examination now required, and after enlistment, be given instruction in stoking and in handling the ordinary tools found on board ship. With our present short term of enlistment, three months is probably all the time that can be allowed for this training. The men should be divided into classes, all those enlisting in a month forming a class. The great object to be aimed at in this three months' course is to make the men put coal in a furnace intelligently, and to make them handy in the use of tools required in the ordinary repair-work of the engine and fire room.

There should be but one class of firemen in the Navy, with a uniform rate of pay, that of the present first-class firemen. The firemen should not be recruited from the coal-heavers, unless it is impossible to get qualified men from the training squadron or from the receiving ships. At the end of a cruise, such coal-heavers as have shown fitness and aptitude should have their discharges so worded that they could readily enlist as firemen at the proper recruiting station, and then get the benefit of the three months' training.

DISCUSSION.

THE CHAIRMAN.—*Gentlemen*:—We meet this afternoon to discuss the subject of P. A. Engineer Parks' paper on training enlisted men for the engineer force of the Navy. It is a very important subject, and one that is growing more and more important as the Navy is being increased with modern men-of-war. Machinery is used to such an extent on the lately constructed naval vessels that to the efficient working of ship and battery some mechanical knowledge is as essential for the seamen as for the firemen.

How this knowledge is to be imparted, what inducements are to be offered to the apprentice or enlisted man to become a skilled mechanic, or even an efficient fireman or stoker, are matters involving an acquaintance with the enlisted man's surroundings, inclinations and aspirations.

To exchange our views on this important subject is carrying out one of the objects which the Naval Institute is designed to encourage. Those who have thought much upon the subject, and those who have not, will no doubt receive, from a discussion of the paper before us, ideas that may lead to a definite and efficient plan.

With this aim in view, I trust each one will indulge in a free and liberal expression of his views.

Lieutenant E. K. MOORE.—*Mr. Chairman and Gentlemen*:—The subject before the meeting is certainly a very important one, and I think we all realize the necessity of trained firemen and machinists for our new ships. The present state of our merchant marine is such that I doubt very much if we could get the number we would require from that source.

The subject is one about which I have not thought enough to wish to put myself on record. However, I take issue with the author on one point, and that is, the selecting of a certain number of the apprentices who enlist on the Minnesota and retaining them for apprenticeship in the fire room. In lieu of that I would suggest that the boys be sent on board the training ships, and when qualified for transfer from those training ships, that they be sent to some school, on shore or afloat, for their apprenticeship as firemen, machinists, or whatever other billet they may choose in the engineer force. In the first place, the boy, or any one else who goes to sea, must have a naval training before he can be capable of doing anything useful on board ship. If the boy was trained and taught the different parts of the ship, how to row, how to swim, how to take proper care of himself, of his clothes, bag and hammock, and, besides this, a certain amount of seamanship, ordnance and soldiering, he would then require no more instruction on board ship except in the one professional branch which he might select or be selected for in the future. If he could then be sent to a steamship to serve his apprenticeship, I think it would be better than to take him as a green boy from the street or farm or whatever other place he may come from, and place him at once in the fire room.

Again, I do not think it a good idea to teach apprentices for the fire room on the steam apprentice ships. In the first place, if we have steam on the apprentice ship it will only be auxiliary, and the machinery will be entirely different from that on any other ship in which he might afterwards serve. The training he would get on the auxiliary steamship would, for instance, be of little use on the Boston, Atlanta, or other new ship. In addition to this, we already have too much to teach the apprentice in the short time that he is allowed to remain on the training ship.

The Minnesota, Franklin, and Wabash are ships of the old type, but might be used for the first part of the training of firemen-apprentices. Then when far enough advanced they could be sent to cruising vessels having boilers and engines of more modern type, there to complete their education and serve out their terms of enlistment. From those that have served their apprenticeship as firemen might be selected a certain number to be re-enlisted as apprentice machinists and distributed amongst the different Navy Yards, to work in the machine shops and on the engines and boilers of vessels fitting for sea. In this way they would get a knowledge not only of the handling of tools, but also of the engines they might be called upon to run in future. Being enlisted, they would not be liable to be laid off on account of want of funds, but would be an addition to the regular force.

Lieutenant J. B. MURDOCK.—*Mr. Chairman and Gentlemen*:—I have not given the subject much consideration, but there are one or two points suggested to me by the paper and by what has just been said. I fully approve of the training proposed, but differ with the author as to the method of carrying it out.

The great need of the service to-day is a higher technical training to fit the men for their duties on board our new vessels. A new class of men is called for on deck as well as in the engine room, and the service would be greatly benefited if the training squadron could supply the latter as well as the former. Owing to the comparatively small number of men allowed the new vessels, the men of the engineer's force will probably have to take part in landing parties, and are, indeed, even now required to be instructed in small arms and machine gun drill. It will be a great advantage if they are given a systematic training, and are subjected to the habits of discipline in which apprentices are educated in the training ships.

I am decidedly opposed to the idea of educating the engineer apprentices on the Minnesota in New York harbor. If the steam training ships which the Chief of the Bureau of Equipment and Recruiting has been requesting are ever built, the natural place to educate boys for fire-room work will be on board those vessels at sea. In that case, let each boy take his turn at stoking, as well as at instruction in seamanship and ordnance, and if any develop peculiar fitness for the work, let greater facilities be afforded them.

I do not think, however, that every boy developing mechanical skill or ingenuity should be assigned to the engineer's force. Machinery is being introduced into every part of our new ships, and a knowledge of tools is very necessary on deck also.

I wish to call attention to the fact that at present the pay of first-class fireman, the only class provided for in the paper, is the same as that of chief boatswain's mate, and this will naturally attract men to the engineer's force, leaving an inferior class on deck to perform duties requiring at least equal skill and knowledge. Our modern training must fit men for the greatly changed conditions of our new vessels; and, if necessary, somewhat of the present training should be left out, as we cannot expect to make our apprentices "Jacks of all trades."

Ensign DENFELD.—*Mr. Chairman and Gentlemen*:—The work in the fire room is too hard and too confining for those who have not reached their full growth. By training boys in the fire room there will grow up an inferior class of men who cannot be depended upon in emergencies. A few years ago the system of training boys in the Navy for the engineer's force was given up after a short trial. There was a marked difference in physical appearance between the fire-room boys and those on deck.

It is very essential that a course of training should be given to the men who enter the engineer's force—for a period of one year, let us say. During this time enough military and technical training can be given to fit men for the routine work on board a man-of-war. At most of the shore stations the necessary course of training can be given, and it will take only a short time on shipboard for those who have completed it to become masters of the situation.

Commander HIGGINSON.—*Mr. Chairman and Gentlemen*:—I cannot help approving of this idea of educating naval apprentices, because it seems to me we stand much in need of some such system. I think that every boy destined for the Navy should receive at the commencement of his career a military and nautical education, whatever position he may subsequently be called upon to fill, and whether before or abaft the mast. It is only by following this general principle that the efficiency, mobility, and harmony of the service can be maintained. The Naval Academy is doing some good work in this direction, and might with profit extend its sphere of action; and now, in filling the engineer force with trained men, let the training squadron do for the rank and file of the service what the Academy is doing for the officers.

As has been remarked by Mr. Denfeld, the boy destined for the engineer force should be of some growth and maturity, and his earlier years cannot be better employed than on board the training squadron. He will not only acquire there the necessary physique, but he will gain that nautical basis to his education which will enable him always to feel at home upon the sea. Many officers have noted how little general interest in the service is oftentimes found in the engineer force, and this unsympathetic attitude towards their surroundings and associates has presented at times a serious impediment to the complete harmony and discipline of the ship. Now it seems to me that this uncongenial feeling may be eliminated by taking boys from the training squadron and training them for the engineer force. Then not only the officers but the rank and file would be possessed of a sailor's knowledge, and be available for use in case of an emergency.

I think there should be no difficulty as to the details of this scheme, and they should be worked out in harmony with the present system of naval training, and under the same direction. It is only a part of a general system of naval education for boys and should be under one head. The boys may be educated for stokers, firemen, or machinists, according to their capacities or inclinations, and either afloat or ashore as may be found most advantageous. Inasmuch, however, as after his double education he becomes of double value to the Government, his pay, if not double, should be in excess of that of the man who is only educated in one direction. This would be only fair treatment of skilled labor, and would offer an incentive to the boys to undertake the additional training. All boys entering the engineer force should be required to serve for a length of time—not less than ten years—sufficient to reimburse the Government for the education bestowed upon them. It must be remembered that, unlike the sailor, the engineer can find a market for his wares on shore, and it is against such a misuse of benefits conferred that the precautions should be taken.

Lieutenant ROHRER.—*Mr. Chairman and Gentlemen*:—It is admitted by all that a skillful and well-qualified engineer's force is necessary on board our ships. The use of steam and machinery is constantly increasing, and the better trained our firemen and artificers are the more power will they develop from a given amount of coal, and with the least wear and tear of machinery. It would be very satisfactory if we could secure a sufficient number from among the boys who have gone through the course of the present training system, and who have arrived at the requisite physical maturity for further training to qualify them as firemen and artificers. What they have already acquired would of course make them so much more valuable in the new field to which they would be transferred. It is a question in my mind, however, whether the fire and engine rooms offer sufficient attraction and inducement to youths who have qualified as seamen to warrant a hope that the engineer's force could be sufficiently recruited in this way. If it can be done, it were well to do it so.

Supposing it cannot be so recruited, I would suggest a system of apprenticeship to be carried out at all our naval stations where boilers and machinery are in constant use. The youths should be from eighteen to twenty-two years of age, of the necessary strength and robustness to stand the work of our more trying fire rooms. They should be shipped as general engineering force apprentices for five years. They should be thoroughly instructed in firing, in caring for boilers, and in handling and using such tools as they may develop a capacity to use. The brighter and more ambitious should receive special training to qualify them as ship's machinists, coppersmiths, blacksmiths, oilers, water-tenders, and the like. Upon passing prescribed examinations for the various positions which the ambition of each apprentice warrants him to try for, they should be put into the general service with the assurance that they are to have the rates for which they have qualified, when vacancies exist.

It appears to me that a valuable set of men could thus be obtained, though they would not have been set up as soldiers. To attain this end, they could be quartered upon the receiving ships or barracks at the various stations, and there receive at specified times the military instruction, which certainly is very desirable and important. Or, these apprentices, after a certain time of training on shore at the naval stations, might be transferred to a steam cruiser especially set apart for the purpose, there to finish their training, and then to be transferred to the regular cruising ships. As to the military training of the engineer's force of our ships, I see no reason why the men composing it should not be set up as soldiers while they are waiting on the receiving ships for transfer to the cruisers.

It seems to me that some system like this will provide the force we want; and it can then be recruited from the existing training system, from the merchant marine, and from the farm and street. Take the competent youths from wheresoever they may come, train them at the naval stations upon an elaborated and sensible plan, turn them into the special cruiser and then into the general service, securing to them the higher ratings for which they prove themselves qualified,—this, in brief, is the plan that I would suggest. What I have said will, I hope, be understood simply as a suggestion which may possibly be of use in solving the problem under discussion.

THE CHAIRMAN.—*Gentlemen*:—As I said in my previous remarks, we must consider the enlisted man's surroundings, his inclinations, and his aspirations. To improve the first, we must make them such that he will not only be enabled to live with all possible comfort on board ship, but also in such a manner as to encourage his self-respect and generate a liking for his life. A very great improvement is being accomplished in this respect in his treatment and accommodations. The nearer we approach a satisfactory state in these matters, the greater will be his inclination to remain where he is guaranteed a sure and permanent remuneration for his services and a just and considerate supervision. The exact course to be pursued to attain these results, although germane to the subject of the paper, I will not now undertake to discuss, nor give my views, except to say that the enlisted man, like every other, must have his aspirations for higher place and position considered and whetted, to obtain from him valuable and beneficial results.

The question of obtaining competent machinists and firemen for the service has not, I must say, engrossed so much of my attention as that of obtaining competent naval seamen, for the reason that I have felt that the duties of these men in the service are so similar to those on all modern steamships that a supply could always be obtained, particularly as the pay in the service is tolerably fair, and, except in occasional instances, the work is not arduous.

The question that has given me most concern is what inducements can be offered to a man to become an efficient stoker or fireman. If a plan can be devised by which men can be trained and retained in the service to fill these positions it would certainly be desirable in every respect. Would a young man on board of a man-of-war have the means of making himself a skilled mechanic, so that he could hope to receive the rate of machinist? I think not. This knowledge he must obtain in a machine shop, either ashore or afloat; and even after he has this knowledge, it is a question whether he will be willing to take a step down and make a cruise as a fireman. The introductory steps to becoming a stoker cannot be taken by a boy. The work requires a full-grown and tolerably strong man, unlike in this respect to the training to be a machinist or seaman, which not only can begin in youth, but it is advisable that it should so begin.

To obtain a supply of firemen and coal-heavers I would propose the following modification of Mr. Parks' plan. On the receiving ships at navy yards enlist men, not under 21 nor over 28 years of age, as firemen and coal-heavers. The qualifications for the former should be a fair knowledge of the duties of the rating, such as is obtained on the ordinary merchant steamer or tug, a common school education, and excellent physical powers. For the coal-heaver, the necessary physical power and a fair character. Have an engineer officer, with the requisite number of machinists, to instruct these men in their duties, affording them all the facilities necessary to this end. There is no doubt but that soon all the receiving ships will be lighted by electricity, and thus an opportunity will be afforded for instructing the firemen in the care of the dynamo and engine.

It would be, in my opinion, an excellent plan to have all the rebuilt monitors of the Miantonomoh class commissioned and stationed in our principal harbors, —one at least at this place,—and to have the firemen, before being drafted, made to go through a short course of instruction on board of them. These vessels could also be used to instruct such apprentices as, having served eighteen months in the training squadron, and shown a fair mechanical ability, may desire to enter the engineer force as machinists. Should naval seamen apprentices, after receiving their discharges on arriving at the age of twenty-one years, desire to enter the engineer force as firemen, they should be given the opportunity to do so, by re-enlisting them under their C. S. C., and instructing them in their duties on the monitors. The great advantage of having men in the engineer force who have received the training of the naval apprentice squadron would add so much to the military character and consequent efficiency of the ship or service that the attending time and expense would be amply returned to the Government.

The plan of educating machinists for the Navy at a navy yard I do not approve. Judging from an experience of three years in one of them, the work is so fitful and uncertain that the apprentices, if retained on the chronic giving out of funds before the end of the fiscal year, are necessarily employed in keeping the shops and machinery in order, and not directly in learning their trade. The Navy will always have to depend in a great measure for its supply of machinists and firemen on the merchant service. If we can leaven the number with some instructed as mentioned, I think we shall be accomplishing about all we can expect or hope for now. England, whose naval training system is probably the most complete in the world, does not, as far as I can ascertain, attempt to train men specially for machinists and firemen. They are doubtless selected from her dockyards and other sources. Commander Chadwick does not mention them in his admirable book on the "Training of Seamen in England

and France." I do not mention this fact as the reason why we should not train our own engineer force, but simply cite the example as showing that the largest navy in the world has not yet been driven to this method of obtaining them. After we have created an adequate supply of trained naval seamen, which is the imperative present need of the service, we shall be better able to strive to create one of machinists and firemen. But until we do furnish a sufficient supply of men for those duties on our men-of-war that cannot be learned elsewhere, further steps than those mentioned I do not think absolutely necessary. We should simply be producing incomplete and unsatisfactory results.

I understand that allowing apprentices to go into the engineer force was tried at one time with good results. An old machinist in the service, now at this station, states that so many wanted to enter the engineer force that the plan had to be given up. That nearly all wanted to go might have been the case, as the pay of firemen is equal to that of the highest seamen petty officers in the Navy—in my opinion a very sad condition of affairs, and one not calculated to obtain and retain the most desirable material for seamen. The pay of the seamen petty officers of the first class should be raised to that of those with whom they rank.

As I have stated in my opening remarks, I have not given this matter the thought I ought, but what I have stated is my opinion at present. Further consideration of the remarks made here, and further reflection, may lead to modifications in my views.

Before adjourning we should thank P. A. Engineer Parks for the interest he has shown and his advocacy of a plan for the improvement of the personnel of the service. It is a healthy indication and one deserving our heartiest co-operation.

The following discussions were received in manuscript from some of those that were unable to be present at the reading of Mr. Parks' paper, but to whom proofs of the paper had been sent with a request for an expression of their views on the subject.

Commodore SCHLEY.—*Mr. Chairman and Gentlemen*:—The paper of P. A. Engineer Parks touching the training of men for the engineer force is in such complete accord with my own views on this subject that I endorse most he has said in his admirable presentation of this great need.

The argument he makes for higher training is supported by the fact that the contrivances employed to obtain high power in our new ships differ so widely from those in common use in our old ships that special training is essential to the men who are to be required to develop this increased power. When it is considered that the new engines are somewhat more complicated in design, quicker in motion, and that boilers differ in form and construction, that higher pressures are to be maintained, that there is a labyrinth of pipes and connections for pumping, that a new system of forced draught is to be employed, that greater horse power per square foot of grate surface must be obtained, that the conditions of air-tight fire rooms change old requirements, it would seem almost ridiculous to expect untrained men to be of the slightest use in our new vessels like the Baltimore, Charleston, or Newark. As I understand the problem, we have a certain aggregate number of square feet of grate surface upon which to convert coal into energy. In the old ships with natural draught the possible horse power was from four to six. In the new vessels with forced draught there have been developed from eight to sixteen horses, with possibilities up to twenty horses. In other words, with the best picked coal we are to require at least 68 per cent more energy in the same area than ever before to obtain the power that is to accomplish the high speed of the new ships.

It goes almost without saying, that if these results are to be attained our men must be trained. I can conceive no other way to bring this result about; indeed, I think that the only reason for the failure to develop the required horse power of the Dolphin and the Atlanta is that the engineer force of these vessels is untrained to the new system. It is safe to say that each trip of these vessels will indicate improved results growing out of better acquaintance and more training with the new machines. This brings me to the suggestion that unless we train our men before placing them on board of the new ships, we shall be obliged to train them after going on board. This means simply that the new ship, under the latter circumstance, will be for several months unfit for duty, during which time she would be easily whipped by vessels of inferior power manned with a trained force.

I am free to say that I am committed entirely and earnestly to this matter of higher training of men who are to serve us in our new ships, and have intended to commence it as soon as we shall have succeeded in securing the steam training ships advocated since my accession to the Bureau.

With reference to the age at which this training should commence, I must differ with Mr. Parks, for the reason that the work to be done by the person trained requires the fuller physical and mental development of a man. The tendency of fire-room work to develop diseases of the heart in the adult would be a strong reason against training an undeveloped boy to this duty. Again, it would appear that the work to be done demands more strength of body and general intelligence than could be expected from a growing lad who learns rather by imitation than by the immediate exercise of his reasoning powers. No: I would train men of twenty-one years and over with more certainty of success and with less probability of injury to their health.

I have merely thrown these views together in the hope that the discussion to follow may give more light upon this subject, or to invite suggestions from others who may have thought upon it.

Chief Engineer GEO. W. MELVILLE.—*Mr. Chairman and Gentlemen:*— Although agreeing in the main with my brother officer that all men need training for their special duties on board ship, as in fact in all walks of life, I cannot compare the engineer department of a modern man-of-war with that of a well-organized machine shop. In the machine shop, from the superintendent down to the apprentice boy, all things work harmoniously, each having his share of the work to do, and each man is responsible for the work done. Every mechanic employed is supposed to be able to do his day's work and do it well, misfits or mistakes causing the man's discharge, the apprentices alone being allowed a little latitude, because of the fact that they are the learners. I learned my trade in a machine shop, and if any man engaged as a machinist could not do his work he was discharged, and here ended the matter.

Not so, however, is this the case in a military organization. If a man manages to be shipped in a certain grade, he cannot be disrated without the form of a court-martial. He is not a responsible person with the danger of discharge from lucrative employment before him. In the machine shop—in fact in all manufacturing establishments—everything is done by rule and line. In a man-of-war fire room this cannot be: the fire and engine rooms are a scene of continually changing conditions and expedient. In the modern man-of-war or iron fighting machine—where we have anywhere from 400 to 800 tons of engine and boiler, and the most of it under tension, almost to the breaking point, either from pressure in the boilers or strain on the moving parts of the engine—the conditions are entirely different from that of the machine shop, and both officer and man must be alert to avoid accident, to substitute one part for another, make quick repair in emergencies, or make one system of pipes or valves do service entirely different from what they were intended for. In certain cases the engines must not be permitted to stop, or the battle is lost or won. Not so in the machine shop: when the bell rings, noon or night, all hands quit and go home. To-morrow morning will suffice to continue the construction of the fabric in hand, and if we are hurried we can put on more hands, and discharge them when the hurry is over.

To my mind, the great difficulty with the engineer force is the fact that there are so very few mechanics among them. A man cannot learn the trade of machinist or smith on board a ship of any kind; and because a man becomes familiar with tools or the use of tools in a crude way, he is rated by the officer put over him to the grade of the artisan class, thus spoiling a good, first-class fireman to make a worthless machinist or boilermaker, so-called. And were either out of employment, the last place they would dare to go and ask for employment at either trade would be in a machine or boiler shop. We might as well expect an excellent coachman to be a coachbuilder in any of its multifarious branches.

There are men shipped or rated in our service to-day in the mechanical branches who are totally ignorant of the trades they are supposed to follow, and who cannot do either engine, boiler, or smith work. I mean men who have not learned the trades, and cannot go into a shop on shore and do a job of work.

Mr. Parks may argue, "So much more the reason why we should drill or teach the men their duties." Firing or handling the machinery may be taught on board the ship, but the trades cannot be. And it is to this class of petty officers the engineer officer must look for intelligent aid in handling and repairing and keeping in repair the vast amount of machinery which is daily growing greater and more intricate. The day has gone by when any man who could shovel coal and pack a stuffing-box on a slow-moving, low-pressure engine of 15 or 20 pounds of steam can be trusted with the high pressures now in vogue, and which are daily increasing. We must have the young, bright, intelligent engineer, who knows his responsibility and danger and can appreciate them, to direct the duller material that does his manual labor and keeps his machinery in repair.

He is required to give confidence to his subordinates by his coolness and intelligent supervision of the moving mass of machinery—not from deck or from his state-room through a speaking-tube: he must be right there among his men, through soot and black, heat and steam. Though he be called ignoble because he soils his hands, if he would be the efficient engineer and serve his Government as he should, he must do all this and more too, and let the pleasure be his that he, too, is a part of the modern fighting machine and the soul that gives it thought and movement. It seems impracticable to me to put men through a course of training for special service on speed trials—except on board of our cruising ships, where they soon get all the training in firing and overhauling the machinery it is possible for them to have—as my experience in the service has been that the men who did the running at sea employed all their time in port overhauling machinery, one ship alone excepted, the Lancaster, which at that time was an auxiliary-powered ship. Selections might be made from the well-known men who are shipped for general service that could be employed for this special duty for steam trials; but where these services are so seldom called for, I doubt if it would be good policy or convenient to hold such a body of men for that service. What would it avail us if we found, by a special force, on experimental trials, that a ship made 16 knots per hour on a coal consumption of 1.6 pounds per H.-P. per hour, if in practice, while cruising, we made but 14 knots and it cost 2.5 pounds of coal per H.-P.? I fear this is a rock on which many persons are splitting. A measured-mile speed trial cooked up and jockeyed for a record is very different from the actual cruising practice, and it is only on these special speed trials when the high speed of ship and economy of engine are shown. When the ship goes out into service, the actual fact of practical running is brought into play; and it is in our service as in all other services, whether naval or merchant marine.

The jockeying for high speed and economy lapses. Steam jackets and special appliances are shut off because they require more care and attention than can be shown them, because of the reduced force on board to attend to them, and the blooded horse with the fire of "Maud S." and her special jockey falls into the traces of the steady-going roadster or dray horse.

Having been attached to the Atlanta, I suppose I should be expected to say something concerning that magnificent ship, so much better than any we have ever had before in our service. We should be proud of her, though some of my fellows differ with me. She has plenty of engine and boiler, and should make 4000 horse power. The cause of her ill-success up to this time has not been alone a want of a trained force so much as a combination of conditions in a new construction, including forced draught, ventilation, arrangement of coal bunkers and bunker passages, and the facilities of working under these new conditions. There are other defects which will be remedied in new constructions, and that will be palliated when she is formally accepted by the Government. Suffice it to say that the Government never before got so much ship for so little money, and the labor this ship has passed through will bring forth good fruit in the new constructions now in hand.

Mr. Parks will naturally ask what I propose instead of his scheme. I too would train men to do their work properly and well ; but I would use the force as now enlisted. I would enlist no man in the artisan class unless he was a mechanic who had learned his trade in a properly equipped shop for the fabrication of machinery. I would not promote a man from the fireman class to the artisan class because there was a vacancy, and because he was a good oiler or water tender. I would promote coal-heavers to all grades below that of artisan, for all my experience has shown me that the coal-heaver at the end of a cruise makes the best fireman. He has been trained and drilled, and is still young and vigorous enough to do the duty of a fireman, and he won't last long. He will soon be burnt out, like an old grate bar, and will soon have to drop out to make way for the new material to be recruited from the able-bodied and most intelligent of the coal-heavers.

I would try to make the men happy so far as lay in the power of the commanding officer of the ship, and make them feel that, although black and grimy from heat, soot, and labor, they were part and parcel of the fighting machine ; that their labor was honorable if well done, and that they shared in the honors of a well-drilled fighting machine ; that they were not damned because they were grimy ; and I would never degrade them by clearing the "brig" of its prisoners and roughs and rogues to recruit the fire-room force in an emergency. By recognizing these men and the labor they perform as necessary and essential to the success of the ship, they too would be made to feel that spirit of friendly rivalry that pervades the other parts of the ship, and it would take the weight off their minds that they are the "damned firemen."

Passed-Assistant Engineer A. M. MATTICE.—*Mr. Chairman and Gentlemen :*—I agree most heartily with the author that something must be done in the way of training men for the engineer's force of our prospective ships, but I differ from him in some respects as to what this something should be. In the first place, as great physical endurance is one of the first requisites of a good fireman, I should object to the enlistment of immature apprentice boys, and would offer inducements for men to enter the service who have had some previous experience in hard firing—on locomotives, for instance. They might be enlisted for a short period of probation, say six months, and if at the end of that time they proved acceptable, they could be enlisted for four years. I would have one or two small steamers in constant use, with forced draught, where these men, during their period of probation, could be trained in the working of modern marine boilers. The tugs of the Fortune class might be utilized for this purpose by replacing their present boilers by smaller ones fitted for forced draught. The men should spend the first six months of their long enlistment on board a steam receiving-ship and at a navy yard where they would be instructed in the use of tools.

But to get such men—and we will not be able to get along without them—

inducements must be offered. In the first place, we must give more pay. I know that this will be objected to immediately, as firemen now get more pay than other enlisted men of the same class. But labor is a merchantable article, and will bring what it is worth, and the more we pay, other things being equal, the better article will we get. Moreover, increased pay is not the only inducement which must be offered in order to obtain better firemen, as well as better men of other classes. The condition of the life of enlisted men on board ship must be improved; the fact must be recognized that they are human beings and should be treated as such. Their mode of messing must be made more decent; they should be allowed more leave of absence on shore after their day's work is done, instead of the infrequent "liberty" (most appropriately named) now granted; they should be paid their hard-earned money once a month, instead of having grudgingly doled out to them various pittances under the names of "monthly money," "liberty money," "mess money," etc.; greater precautions should be taken against the awarding of unjust punishments; a practicable appeal from arbitrary decisions of commanding officers should be provided for; and last, but not least, the firemen should not be required to do any more work than is absolutely necessary outside the engineer's department. They are, on the more modern ships, the hardest-worked men in the ship's company, being employed from early morning until late in the afternoon overhauling and repairing machinery; and after this work is done they are exercised on deck in evolutions in which they could not possibly participate in action, as they would then be all required at their legitimate work below.

Then, again, besides getting trained men, we must have more men. The Colossus, which the author quotes, worked 35 "stokers" in the "stokehold" when she made her 7488 I. H.-P., or one fireman for every 214 I. H.-P. At this rate the Atlanta should be allowed 17 firemen on each watch in the fire rooms, supposing that she had as good coal as the Colossus; but with Cumberland coal the extra amount of work would necessitate the employment of 20 per cent more men.

Men accustomed to working fires only under natural draught are at first almost useless on forced draught fires, and not only require training, but they must be kept in condition by constant practice. The severity of the labor on forced draught fires increases much more rapidly than in the same ratio as the I. H.-P. It is only too probable that ships after running their full-power trials will never again use forced draught except in case of emergency, and then the firemen will be found wanting, for lack of practice. Forced draught should be used, on a portion of the boilers at least, for a part of every run, and every ship should have a twenty-four hours' full-speed run at least once a year, to bring the men up to as near the proper standard as possible.

But I must ask to be allowed to digress from the main subject to take exception to the author's comparison of our I. H.-P. per square foot of grate with that of various English ships. In the first place, it is idle to suppose that with Cumberland coal we can get as good results as those obtained from Nixon navigation coal. In Mr. F. C. Marshall's recent article on high-speed marine engines, he gives the results of trials of both Nixon and Cowpen coals in the same boiler. The Nixon coal evaporated 8.57 pounds of water from and at 212° F., while the Cowpen coal (corresponding to our Cumberland) evaporated but 6.97 pounds. Besides this, our coal contains considerable ash, while the Nixon coal is so clean that the English ships run their full-power trials without hoisting ashes. The author's reference to the expected I. H.-P. of the Nile is unfair in another respect, as she has triple-expansion engines, while the Atlanta's engines work with double expansion, and so the increased performance per square foot of grate is in part due to the more recent design of the engines, and not to better firing.

And here, too, I must protest against the now too common practice of comparing the official results of our trials with the newspaper reports of the trials of foreign ships. For a long time I put implicit confidence in reports of trials which appeared in leading engineering papers, but I have found so many of them false that I have come to such a state of incredulity that I am loth to believe any reports whatever unless the strongest proof of their correctness is furnished.

Experience has taught me that men ordinarily of the highest integrity regard the horse-power of their engines as a perfectly legitimate subject for exaggeration, and would no more hesitate to romance on this subject than would an angler on the weight of his catch, or a mountaineer on the length and girth of various snakes which form the themes of stories which he loves to narrate to open-mouthed and credulous listeners. This practice is of no sudden growth, but has gradually developed. One man shows his engine to make a certain economical performance, and his neighbor, to keep up his reputation, must needs beat his record; and so it goes on until those builders who would like to give truthful accounts of their trials are afraid to do so because they would appear to be behind the rest of the world. All sorts of tricks are resorted to, but the principal ones are the use of overrated indicator springs, and increasing the speed at the moment that the indicator diagrams are taken. Let me cite an example: Within the past year there was received at the Navy Department a set of indicator diagrams from the triple-expansion engines of one of the finest steamers in the Transatlantic service. Here, thought I, was some data about triple expansion that was worth having. The engines were designed by one of the most eminent of English engineers; the ship and machinery were built by a famous firm on the Clyde; and the ship is owned and run by one of the best companies whose vessels ply the Atlantic. There was no need for deception here: the reputation of all parties concerned was too firmly established to need any such assistance; but need I say that my faith in human integrity went down to the lowest ebb when the first application of the given indicator scale showed *seven pounds more initial pressure in the high-pressure cylinder than the pressure in the boiler?* Probably they had counted on nobody being inquisitive enough to examine into such unimportant details. These engines were said to develop a horse-power on 1.32 pounds of coal per hour, but the power actually shown by the diagrams (without any correction of the scale) proved that these figures were entirely too low, as the consumption of coal per day was known from the ship's log. Going a little further, I compared the revolutions at the time the diagrams were taken with the ship's run for the day, and found that the cards were a set of "show cards" taken with the engines running at considerably more than their average speed. This brought the cost of the I. H.-P. still higher. But I was not content to stop here; the indicator must be made to bear still more testimony against itself. Now, no matter to what unknown extent an indicator scale may be falsified, and no matter whether or not we know the correct number of revolutions, there is an unfailing test that may be applied. As the specific weight of steam varies almost directly as the steam pressure, the ratio between the weight of steam shown by any given indicator diagram and the work shown by the same diagram will be very nearly constant, no matter what may be the scale of the indicator. Applying this test to the diagrams in question, I found that they showed 14.76 *pounds of steam per I. H.-P. per hour*, no allowance being made for losses. It would take a phenomenal boiler, excellent coal, and better water than we have on this side of the Atlantic, to make this amount of steam without the expenditure of a great deal more coal than the quantity claimed.

Another case very similar to this was the trial of the quadruple-expansion engines of the Rionnag-na-Mara, where the cost of an I. H.-P. was said to be 1.125 pounds of coal per hour (vide *Engineering*, April 9, 1886). An English engineer had the temerity to question the accuracy of the trial, and showed that the indicator diagrams accounted for about 14 pounds of steam per I. H.-P. This brought down upon him the wrath of several other engineers, one of whom made himself ludicrous by accusing the critic of unfairness in taking his measure of the steam where the diagrams showed a maximum quantity, instead of from the point where the least steam was indicated.

Going back several years, I may cite the trials of U. S. S. Vandalia and H. M. S. Garnet, which are tabulated by Brassey in Vol. I. of "The British Navy." The Vandalia, at 2033 tons displacement, burning anthracite coal, made 12 knots per hour on 1200 I. H.-P. The Garnet, at 2120 tons, burning bituminous coal, made 13 knots on 2000 I. H.-P. Both ships had the same area of grate surface. By Froude's law of comparison, the corresponding speed and power of a vessel on the Vandalia's lines, but with the displacement of the Garnet, would be 12.08 knots on 1263 I. H.-P. The I. H.-P. for this ship at 13 knots would then be, by a simple calculation, only 1575, instead of the 2000 said to have been made by the Garnet. The two ships are fairly comparable by this method, as their coefficients of fineness are practically the same. But if the published reports of the Garnet's trial are correct, she must have somehow wasted $2000 - 1575 = 425$ I. H.-P. I am inclined to think, however, that no such careless engineering was done by her designers and builders, and that the horse-power was exaggerated in the reports made public.

There are many still earlier indications of this tendency to give incorrect reports of engine trials. It is now nearly a quarter of a century since Dupuy de Lôme publicly remarked that it required more power to drive English ships than French ships of similar size at similar speeds, and attributed this to the finer lines of the latter ships. This aroused the ire of the English shipbuilders; they scoffed at the idea of Frenchmen producing finer models than theirs, and in order to prove their position they were compelled to virtually acknowledge that the increased horse-power was due, not to the greater resistance of the hulls, but to the less resistance of the indicator springs.

We often hear of trials of very short duration, but they seem to be considered by many people to be of the same practical value as longer trials of other ships, and are quoted on terms of equality with them. For instance, the performance of the Naniwa Kan is frequently compared with that of some of our ships. She is reported as having made 7650 I. H.-P., or at the rate of 19½ I. H.-P. per square foot of grate. Her trial took place over a course of 9.6 knots, one run being made in each direction. The first run, with the tide, was made very nicely indeed, but the run against the tide was not so successful. Before two-thirds of the course had been passed over the steam had run down from 90 to 72 pounds, and the revolutions from 123 to 117; and here the reports of the trial abruptly end. And now it turns out that during these short runs *no water was fed into the boilers*, the trials beginning with water at the tops of the gauge glasses, and ending with no water in sight. The unfairness of comparing such a trial as this with a carefully conducted six-hours' trial must be patent to all.

These are but a few instances which I might mention where the public has been deceived by false reports of trials. The great trouble about the accounts of most trials is that sufficient data is not given and the results cannot be analyzed.

I must apologize for having made this long digression from the subject of the paper under discussion; but I have seen so many proofs of gross exaggeration in published reports of foreign engine trials that, the author having referred to some of these trials, I could not resist the temptation to show the character of some of these reports.*

Passed Assistant Engineer BAIRD.—*Mr. Chairman and Gentlemen*:—I am much gratified to see the subject of training the engineer force brought before the Institute, particularly at this time, when new and powerful steamships are being added to the Navy. The problem of training this force is not new; those

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*Since the above was put into print, the Alliance, using ordinary steaming coal as it came from the bunkers, has made a maximum performance of 12.4 I. H. P. per square foot of grate, and a mean of 11.1 I. H. P. per square foot of grate *for a ten hours' run* on regular service, with apparent ability to keep up the same performance indefinitely. This, however, cannot be fairly compared, on a grate-area basis, with the performances of the English ships, as the Alliance's boilers were designed and built for natural draught only; the forced draught having been introduced at the last moment in order to test a new system of applying the blast. And not only were her boilers not properly proportioned for forced draught, but she was using steam of only 78 pounds pressure in engines designed fourteen years ago and in almost constant use for the past twelve years, while all the foreign ships which are reported to have made such superior performances use much higher pressures in engines of the very latest design.

In order to show that I am not alone in condemning the reputed performances of foreign ships, and in deprecating comparisons between them and our own vessels, let me quote from a late number of one of the leading English service journals (*Admiralty and Horse Guards Gazette*, April 16, 1887, page 242): "We are strongly opposed to the present system in regard to the steam trials of Her Majesty's ships. *As criterions of speed they are perfectly useless and utterly delusive.*" A. D. M.

of us who came into the Navy in the days of side-wheel steamers with jet condensers, and have served through the changes that have passed, have witnessed and have taken part in various organizations, methods, and experiments in the matter of turning our force to the best advantage. There was a time when our force was a good one.

Before touching upon the points so well expressed by the essayist, I beg leave to recall, as a matter of history, some of the forms of organization through which we have passed, that we may be the better able to arrive at a choice, by preventing a repetition of what has worked badly. When I entered the Navy of the United States, during the War of the Rebellion, there was a large number of engineers in the Navy, particularly in the lowest grade of the corps; there was also a large number of merchant-service firemen enlisted in the service. On board large ships the fire room was in charge of a junior engineer, who also 'tended water; the rule was at that time to run the ships at full speed, and to force them frequently; the engineer force was accustomed to urging the fires, and the men either became skillful firemen or broke down completely in a short time. Discipline was at that time good; a commendable emulation existed between the watches as to which should excel in revolutions, and it was at that time conceded that the best result depended more on the engineer in the fire room than on his senior in the engine room. He was the fellow who handled the men; he was the fellow who was looked to "to get the steam." With this in view, and a hope of promotion (which was rapid at that time), the young engineers were stimulated with a desire to inform themselves as to the best method of managing fires and *managing men*. They quickly learned to utilize the men to best advantage, and the men readily learned to work to each other's hand.

The firemen were rarely called upon to perform any duty on deck, and seldom complained of overwork in the fire room, so long as the division of labor was equable. The engineer force was divided in a way to do "the greatest good to the greatest number." When all hands were called to quarters, the watch in the fire room remained there, the first relief went to the steam-pumps and hose, and the second relief to the powder division. The advantages of this distribution are evident. The force was at that time considered as belonging exclusively to the engineer's department, except at quarters, when a part of his men served in the powder division. A boat's crew or a landing party of firemen was always under an engineer; there was no mixing of the men from the several departments of the ship; the engineer's department was then managed very much as on board a merchant steamship.

At the end of the War of the Rebellion the Navy Department began to economize by reducing the number of men in the ships, by placing restrictions on the use of coal and enforcing greater use of the sails. A regulation still exists which forbids the commanding officer from sanctioning more than two-thirds the steam power being used except in cases of emergency, on which occasions he is required to make a special report to the Navy Department. Nor is the two-thirds power defined; it is not known whether the Navy Department meant two-thirds of the power of the boilers when new, or two-thirds of the power of the boilers as then existing. It is interpreted in more than one way, and on the construction put upon this regulation sometimes depends the reputation of a vessel for speed. I made a cruise on board a gunboat just after the close of the war, when this regulation was new. The vessel was provided with blowers for forcing the fires, which would increase the rate of combustion more than 50 per cent. With these blowers in operation a power of almost 1500 indicated horses had been reached, and a speed of 13½ knots had been exceeded. The vessel had been in use two years, and the boiler pressure had been reduced somewhat; the question arose as to what was full power and what was two-thirds power; the decision—on board the ship—was "all we can get with eight-tenths of the furnaces with natural draught," which resulted in the development of about 800 indicated horse power and a speed, in smooth water, of 10 knots per hour. During all my years of sea service since that period I have seen but one United States Navy vessel run at full speed for an hour.

Not only are we prohibited from exceeding two-thirds the power, but admonished to be exceedingly economical in the use of coal; in fact, I have known the limit of coal per hour to be so small that the problem was to prevent the fires going out entirely. To economize still further, the Navy Department, about the year 1870, abolished the firemen and substituted seamen-extra, ordinary seamen-extra, and landsmen-extra, in lieu of first-class firemen, second-class firemen, and coal-heavers, respectively. The purpose was to sail the ships, using steam to enter and leave port and in emergencies. To accomplish this more fully, the sail area of many vessels was increased; barques were changed to ships, and royals were provided to vessels which had hitherto had nothing above topgallant sails; and that the drag of the propellers might retard the vessel's sailing less, two-bladed screws were substituted for four-bladed ones,—and it was believed that the Navy would be greatly benefited. At this time the junior grade of engineers was abolished, reducing the engineer corps about 50 per cent. The ships could not, therefore, have an engineer in the fire room; in fact, it sometimes occurred that no old fireman could be found among the seamen-extra (who were detailed from the deck when we got up steam), and there was sometimes difficulty, if not danger, in the matter of 'tending water. Of course it was an admirable arrangement for wasting fuel, but as the ship sailed most of the time, this loss was not so great as might be expected. The men being shipped as seamen, etc., were no part of the engineer's force; when they worked in his department it was on a temporary detail, and the same men were not always detailed, so that "training" was out of the question.

The Navy Department, in its wisdom, recognized the mal-organization and reinstated the firemen in their original ratings and wages. The rating of machinist was substituted for that of junior grade of engineer: it had many advantages, but more disadvantages. The ratings of boilermaker, blacksmith, and coppersmith have been created, and though found desirable, the two latter have for some reason been discontinued. The short-handedness of the crews still exists to such an extent that "emergencies" requiring the assistance of the firemen and coal-heavers on deck are rather the rule than the exception. But with the labor-saving machines—steam windlass, steam hoisting engines, steam steerers, steam ash hoists, etc.—now being generally utilized, as well as the diminished sail area which is being introduced into the ships of latest improved design, we are inspired with a hope that we may again have a division in fact, and an opportunity to train it.

I beg, however, to differ with the essayist in regard to his comparison of results reported from British trials and those made by our own people. Our experience with an air-tight fire room commenced with Mr. Dickerson's design of the machinery of the Pensacola in 1861. It was a failure. With the blowers doing their utmost on board the Atlanta, the pressure in the fire room was $1\frac{1}{10}$ inches of water. To obtain a more rapid combustion, and greater power from the same boilers, these machines will require to increase in power in a higher ratio than does the rate of combustion, on account of the increased leakages; and to obtain the powers claimed by our transatlantic cousins, the figures reach doubtful proportions. The practical difficulties of the air-tight fire room, and the advantages which appear in the Bureau's design of the blast in the Newark, will probably lead to the general adoption of the latter, which, if developed, may put those gigantic powers within our reach. By the use of the blower, our regular navy ships developed as high as 7.57 horse power per square foot of grate surface, during the early years of the war. When the boilers of these vessels were worn out they were replaced by boilers of equal size, *but without the blowers*, and of course the vessels were not as fast, nor could their machinery develop as much "horse power per square foot of grate."

So far as the power developed by the foreign ships is concerned, I must say I do not believe the reports are correct, for the reason that, for the same speed of a given-sized vessel, they report a much higher power than do the French or Americans. The French people raised this doubt before we did. Nor is this exaggeration confined to their Navy. In 1872, when I served in the South Pacific, there appeared several large new screw steamships belonging to the P. S. N. Co. These vessels had compound engines, for which an extraordinary economy was claimed. I visited many of these vessels, and, though never permitted to see their log book, I was given great facilities for examination. The speed of these fine ships and the power developed by their engines, as calculated from the indicator diagrams, balanced very well, but the amount of coal said to be consumed made it appear that an indicated horse power was developed for less than a pound and a half of coal per hour. Of course I did not believe it, though I was sometimes placed in a position which made me feel like the twelfth man on the jury who "never saw eleven such unreasonable men in his life." Later on, however, we obtained from the commanding officers of these vessels extracts from the noon reports of the engineers, which showed a consumption of 55 tons of coal instead of 36, which brought the horse power up to 2⅛ or 2¼ pounds of coal per hour. The unit of measure of the economy of these vessels was in tons of freight per pounds of coal; the comparison of the new engines of war vessels to-day is in indicated horse power per pound of weight: the competition is sharp; the reward is great. There is no doubt about the powers having been enormously increased for a given weight of engine, but I believe the reports from the other side of the water to be greatly exaggerated. By a weak spring in the indicator, or by other jockeying, the power may readily be exaggerated. I am informed that the reports of the trials of British war vessels are not signed by any one; if this is the case, who is responsible for their correctness?

There is probably not a single engineer in the Navy who is not convinced of the necessity for trained men in the fire room, particularly for the vessels now building. I am satisfied that if a man has endurance, weight, and "gumption" he may become as good a fireman in three months as in three years. There is an art in firing, as in every trade, and it is by no means the man who labors hardest that gets the most steam. It is, however, nonsense to put a boy or a light man at a heavy fire; such may be utilized in the engineer's department in many ways, but not at the fires. A boy, if possessed of gumption and good habits, may soon be trained to run a steam launch, or to oil, and will soon become a "handy man" in the engine room. The lifetime of a fireman has been variously estimated at from three to nine years (about the same estimate has been put on puddlers, whose work is before a hot fire)—perhaps a mean, or six years, would be a fair estimate of the duration of this craft or trade; it is evident then, if we are going to get good results from our men, we can afford but little time for "training," so must select good, hardy material, and combine the training with useful work. To have an efficient watch of firemen, it is essential to have a man over them who knows how to regulate them, and who can enforce his orders. The men should not be permitted to shift watches, but the same men should be kept together, that they may know each other's ways and work to each other's hand. The firing of furnaces in sequence is essential to economy and to high results. The order of cleaning the fires has an importance which must not be overlooked. The watch in the fire room should know what fires are to be cleaned by the succeeding watch; there should be an hour for cleaning each fire. These are about all the general points that can be given. The engineer and the water tender are dealing with problems of nature; the elements are constantly varying, and they must shift their constituents, sacrificing one if they would produce another.

It would be much better, on board our war vessels, if the chief engineers had more control of their divisions, and had the same authority over their enlistment as on board merchant ships. As at present practised, the enlistments and discharges of firemen are made by another officer, and on the discharge a fireman's "proficiency in rating" is estimated by a line officer who necessarily has not the means of personally knowing the merits of that qualification. The small discharges of firemen bear the signatures of several officers, but never that of the chief engineer. On board a merchant steamship the chief engineer has all to say about the liberty of his firemen; on board the ships of the Navy it is not so. It is the custom, by the courtesy of the executive officer, to consider the liberty of the firemen recommended by the chief engineer, but the latter has no recognized right in the matter, and it sometimes happens his wishes are entirely overlooked. Firemen and seamen are punished alike for similar infractions of the regulations or law, but under the present organization extenuations have not always the same effect; for example, a fireman and a seaman may overstay their leave alike, and be quarantined for the same period; the excellence of the former, in his duties below the decks, is hidden from the eyes of the executive officer, while the excellence of the latter is every day apparent; the latter is sometimes rewarded by a release when the former is not. This has always been a source of complaint of the firemen.

The higher wages and the advantages of reaching home often are probably the two principal reasons for firemen preferring the merchant service, though the greatest complaint of these men is about doing drills and work on deck. An old man-of-war fireman rather likes it; he takes advantage of the chance to "wash up," at which process he consumes abundance of time; when the drills are over he takes considerable time "shifting" into his working clothes, and by the time he returns to the fire room he hears "mess gear" piped and rushes on deck to devour his rations; in this way the drills interfere seriously with the efficiency of the engineer force.

I believe the Navy would be more efficient, the ships faster and their machinery in better order, if the firemen were confined exclusively to the engineer's department, even if the fascinating drill of topgallant and royal yards were sacrificed to that end.

Chief Engineer R. B. HINE.—*Mr. Chairman and Gentlemen*:—Mr. Parks' paper calls attention to a crying need of the Navy—a need never felt so much as now, and one which in the near future will become still more imperious. Our new ships are to be steamers. All will depend chiefly, and some entirely, on steam as the motive power. To be efficient, these vessels must have efficient engineer departments. It must not be forgotten that any renown gained by our naval commanders will be based on their having efficient ships and crews as well as officers.

It will be well to have the men and artificers of the engineer's force trained for a time on board steam training or school ships; but I think Mr. Parks overestimates the amount of skill needed by about two-thirds of the force. The duties of second-class firemen and coal-heavers are easily learned. What is wanted from these men is a very moderate amount of skill, combined with great endurance and perfect discipline. And it is here that we are most lamentably deficient. Among engineer officers I have heard but one opinion, and that is, that the discipline in our engine rooms has been steadily deteriorating since about the year 1869, when the ratings of firemen were abolished, and "seamen-extra" created in their places. Although the ratings have been restored, and the pay increased, the discipline has continued to become worse and worse, and this I attribute to the fact that the control of the men of the engineer's force has been more and more withdrawn from the chief engineer—the officer who is held responsible for the department in which they serve, and under whose direction they are supposed to work. Now, it is no uncommon thing for machinists or firemen to be given leave to go on shore without the knowledge of the chief engineer, and without reference to the work in the engine or fire rooms on which they may be engaged. And it frequently happens, almost daily in fact, and sometimes more than once a day, that the whole engineer's force is called off from its work and sent on deck to help to spread awnings, furl sail or the like, the fire room being cleared by the master-at-arms. This is ruinous to the discipline of the engine room. The men, seeing that their duties below are thus made of secondary consideration to sail drill or other evolutions of that kind, come to regard them as secondary, and cease to take that interest in them which they otherwise would do. Seeing, too, that their liberty on shore, monthly money, and other indulgences depend in no way on the manner in which they satisfy the chief engineer by their skill and zeal in the performance of their duties, they have come, as a rule, to have little regard for the approval of that officer, and they will carry out his orders in such way as may be easiest and most convenient to themselves.

Every ship's company should be moved and actuated by one will—that of the commander. The commander's command is general, and he handles his ship and crew through his executive and divisional officers. In battle, or at quarters, and at all other times, the officer who is in charge of any subdivision of the ship's company, and who is responsible for their performance of duty, should be to those men as a commander, and his orders should be obeyed by them with as much alacrity as if they were issued by the commander in person. This is especially desirable in the case of the engine-room force, as in battle their duties are performed under the eyes of the engineer officers alone, and they will lack the stimulating effect of the observation of the commander.

Only those who have spent some time in a modern fire room where a forced blast is used can appreciate the strain on the physical and nerve powers of those there employed. The heat, even in a temperate climate, is apt to be excessive, and the working and cleaning of the fires will task the strength of strong men to the utmost. And I have seen men of a good deal of experience as water-tenders unnerved by the violent fluctuations of the water level in boilers where the combustion and evaporation were being pushed to the highest limit. Under circumstances like these, the highest degree of discipline is imperatively demanded as the only price of efficiency.

To improve and establish the discipline of our engine rooms, I suggest the following changes:

1st. Liberty on shore and other indulgences to be asked and granted only through the chief engineer.

2d. The men of the engineer's force who may be employed in the engine or fire rooms not to be called thence during working hours, for any routine drills or evolutions except general or fire quarters.

3d. Instead of having the firemen drilled at small-arms, etc., on specified days of the week, have them drilled so many times a quarter, the chief engineer to arrange the times so as to interfere as little as possible with the work under his charge. Under this arrangement, the men would get more drills than they do now, as under the usual system drills are often omitted on account of pressing work in the engine room or unfavorable weather.

These changes, carried out in their spirit as well as to the letter, combined with the instruction before alluded to, will enable us to get the best possible performance out of our ships.

One thing more as to machinists. We could get and retain the best class of men if we provided for each alternate enlistment being spent on shore, the men being employed at navy yards at the current rates of wages. Men of stability and character, such as we need in these positions, are often married, and are unwilling to spend all of their time away from home. They would make the best men to employ on board ships fitting for sea, and those whose shore enlistment had expired could, on re-enlistment, be drafted to the ships on which they had been employed.

Chief Engineer BROOKS.—*Mr. Chairman and Gentlemen*:—I had promised myself the pleasure of listening to the reading of the interesting paper of P. A. Engineer Parks, but at this late day I find I cannot be present; not that I wish to discuss this paper, but to coincide with him in his views, and urge that something must be done in the way of training the engineer force in the Navy if we are expected to make the trials of our ships of war successful, and, as cruisers, make them economical and useful.

The fire-room force of ante-bellum days is not the material for these latter day improvements; we are at least abreast of the times, and face to face with the increasing demand for greater speed for our big ships, as well as for our smaller ones, and with the least possible consumption of fuel. In order to meet this demand, the engineer force on board ships must be possessed of a higher degree of intelligence than that usually found among the firemen, and they must be trained for their duty, which is new and varied.

This training can be commenced on one of the training ships, and after two or three months the men will be ready to send to a cruising vessel to complete the work. On board ship they should be shown the same consideration as other enlisted men.

I have known all hands to be called after morning quarters (this call includes the engineer force) and worked on deck until seven bells; then after dinner the deck hands were allowed to lie around and amuse themselves as they wished, but the engineer force would be required for work in the engine department until supper time, then to respond to another call of "all hands send down topgallant yards."

The apprentice system is a good one; but boys under 17 years should not be enlisted. At the expiration of the term of service the chief engineer of the ship should be the proper person to decide whether or not the man or boy in the fire-room force is entitled to a continuous service certificate and good conduct badge.

Teach and encourage the apprentice with the certainty of promotion to the grade of machinist as a reward of merit. Improve the status of the machinist, give him better quarters on board ship, separate him from the enlisted men, and I am satisfied that we will in a very short time have a much more efficient and trustworthy set of men on board ship.

JARVIS B. EDSON, M. E., of New York.--*Mr. Chairman and Gentlemen* :— Professor Tyndall has somewhere told us that we need but walk through the shops of Woolwich, or any of the great factories where steam is employed, to become impressed with the magnitude and extent to which heat, manifested in the form of steam, becomes a helpmate to mankind. But I think if he had, for his illustration, suggested a sojourn in a modern vessel of war, with its mighty engines for propulsion and its innumerable smaller ones for almost every conceivable purpose, and had seen its mighty furnaces giving life, activity and success to the whole, he would certainly have commended it as a somewhat fitting exemplification of his "Heat as a Mode of Motion." Do not fear that he would have contemplated the machinery to the neglect of the coal pile, with its theoretical, dynamical efficiency, or to the neglect of the all-important question as to how the proper combustion of this legacy of the carboniferous epoch was effected. To him each unit of coal would have represented a certain amount of stored-up energy, theoretically valuable according to its composition, and practically valuable according to the distance it had travelled from the mine added thereto. To such a mind frugality is but the natural outgrowth of a knowledge of the article and of its possibilities, and to misuse or to waste that upon which much may depend, would be to him as though a man bound for the Arctic regions were to be wasteful of his provisions from the outstart, forgetting the important fact that their value increased rapidly according to the distance carried and quantity remaining.

Were such intelligence to be found in the material from which firemen are made, even then skill born of experience would be required to constitute a competent fireman.

Certainly no defense can be found for the almost indifferent manner in which coal is left for ignorance to convert into useful effect. Such a thing as the proper combustion of the coal, and its conversion into the utmost heat possible, and how to reach the best results, receives but the most meager attention from the engineers of the present, and none whatever from the men whose ignorance prevents their even caring. Frugality, if ever approached, ends whenever it becomes necessary to limit the consumption of pounds per diem ; while the pounds per horse power developed per diem are hardly considered, if at all. Employes of almost any other class might be either ignorant or neglectful without necessarily causing serious accident to follow ; but when such a one becomes the custodian of such a magazine of energy as a steam boiler, active intelligence is demanded both for safety and economy, and no man should ever be allowed in any important position in connection with the operating of boilers unless fairly well conversant with the subject. Because a man is a fireman, does it signify that he shall be nothing but muscular development and incapable of instruction ? That men should be thoroughly fitted for and trained as firemen seems as self-evident, so far as the matter goes, as the necessity that men should be trained for engineers before being allowed to act as such. How they are to be best fitted for such duty may admit of many solutions, but certainly is it true that it will repay the Government well in the fuel saved alone, for any expense likely to attend the proper instruction of its firemen. Ten to twenty per cent of fuel saved daily may represent many dollars during a year's steaming, and men effecting such economy may well receive a rating and compensation somewhat in accordance therewith. It would seem that the proper place for the instruction in such duties would be on board of vessels while not otherwise engaged, and steaming for the express purpose of affording practice and instruction to a set of men, who may be the operatives, and in the presence of others who may be receiving instruction, as witnesses. With a constant load on the boilers, in the way of certain revolutions per minute, competitive runs of four hours each would go far toward determining the skill with which an experienced man would compare in the consumption of fuel for such period with those under instruction. In some such way would men soon learn to appreciate the subject of proper combustion, measured in terms quite comprehensible to them, such as the distance made and the revolutions of the engine effected.

While this special instruction is to be commended, it does not, in my opinion, necessarily follow that efforts should not be made in the same direction on board of every naval vessel, while under steam, on the part of the engineer force accompanying the same; because, while perhaps not so rapidly, but quite as effectually, can men become qualified in the regular practice of the service. Professional pride on the part of the engineer of the watch should certainly demand that he pay the attention necessary to the end that the coal with which he is provided should be properly used—used as though it were paid for by himself—so as to get the utmost efficiency from it. In the ordinary practice on land no such favorable opportunity can be obtained for the practice of frugality under intelligent management, but in the Government service great opportunity exists for the proper edification of the men in the fire room as to the proper methods of firing with the various kinds of fuel provided them. I consider the object of the paper of the evening of great value, as the subject is too commonly overlooked just where much better results should be looked for; and if provision is made for teaching men how to fire, they will be encouraged therein, well knowing that, after their enlistment expires, they will stand a better chance of finding employment on shore at more than laborer's wages.

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.
MAY 11, 1887.
COMMANDER C. L. HUNTINGTON, U. S. N., in the Chair.

IRON AND STEEL, AND THE MITIS PROCESS.

BY W. F. DURFEE, M. E.

Mr. Chairman and Gentlemen:—I am announced to speak to you this evening upon "Iron and Steel, and the Mitis Process"—a subject manifestly too vast to be discussed comprehensively in a single lecture.

I shall, therefore, confine my remarks, relative to iron and steel, to certain observations and conclusions made during a somewhat intimate practical acquaintance with these metals for the past thirty years, which I regard as contributing to a correct understanding of their structure, and to their proper treatment in the course of manufacture. I shall then, in conclusion, offer a description of a recent and most promising improvement in the metallurgy of iron and steel called the "Mitis Process."

Allow me first to endeavor to answer the question, "What is wrought iron?" One of the greatest obstacles to a correct apprehension of this question is this:—the way in which a mass of wrought iron is built up is not generally well understood, and the difference of its structure from that of a homogeneous material is not fully comprehended. The term wrought iron is popularly supposed to designate a metal; but it is really the name of a mechanical admixture, which, at its best, consists of clusters of crystals (which may with propriety be regarded as compound crystals) of pure iron separated from each other, as the result of the manipulative processes employed, by films or threads of an unavoidable impurity called "cinder." In the manufacture of wrought iron, the "pig," or other variety of cast iron, is first deprived, in a more or less imperfect degree, of carbon and other impurities, by what is known as the "puddling process." This process may be briefly described as consisting of four distinct operations; viz.—

1st. The melting of the "pig iron."

2d. The "boiling" of the melted metal in a bath of liquid "cinder" (composed mainly of silicate of protoxide of iron), until the iron (which, owing to its loss of carbon and other impurities, can no longer remain fluid at the temperature employed,) begins to solidify in the form of small granules or crystals, which can be seen moving amid the boiling "cinder" like white-hot peas in a red-hot soup. When the iron begins thus to granulate or crystallize, it is said to be "coming to nature."

3d. The collection by the puddler of these granules or crystals into distinct masses called "balls." These contain much "cinder."

4th. The "squeezing" or "hammering" of these "balls," while still at a welding heat, into more solid masses, which are called "blooms." These contain much less "cinder" and other impurities than the "balls," but are far from being uniform in structure.

The "balls" above named may with propriety be regarded as white-hot sponges of iron saturated with liquid "cinder," which fills all their accidental and irregular cavities.

When the "balls" are "squeezed" or "hammered" (this last operation is often termed "shingling"), for the purpose of expelling this "cinder" and welding the granules or crystals of iron into a homogeneous mass, the attempt is never wholly successful; for the "cinder," as the metal cools, quickly assumes a pasty consistency and flows with difficulty, and all that portion of it inclosed in the interior cavities of the "ball" is simply flattened out or elongated. Hence it will be seen that the "bloom" is composed of a compacted mass of granules or crystals of iron, separated from each other by films or strings of "cinder" of very irregular dimensions.

When speaking of crystals of iron, I mean minute ultimate units of that metal, bounded by well-defined planes, whose intersections always form salient angles. A number of such crystals may cohere and form an aggregation, having bounding planes similar in outline and relative arrangement to those of any single crystal. Such aggregations, or compound crystals, vary in size, and are often regarded as single crystals and spoken of as such, just as we speak of crystals of galena or calc-spar, when, as a matter of fact, the ultimate crystal of each of these substances remains undiscovered, and as undiscoverable as the boundaries of space.

These large or compound crystals of wrought iron are, in themselves, practically homogeneous: that is to say, the ultimate crystals of which they are composed are not separated and kept apart by any foreign substance, but are as nearly in actual contact as the law of cohesion, in obedience to which they are formed, will admit.

Now let us see how a "bloom," the crudest form of a mass of wrought iron, differs in structure from the homogeneous compound crystals of which it is chiefly built up. Such a mass of wrought iron is an aggregation of an indefinite number of such compound crystals as have been described, which are separated from each other by films or threads of "cinder" of very variable thickness; but which, notwithstanding, are mutually attracted with a greater or less degree of force, the minimum value of which is the measure of the cohesive strength of the mass.

Now let us follow the "bloom" as it progresses towards the form of a commercial bar of wrought iron, and examine carefully the structural changes which take place during such progress. When a properly heated "bloom," or other similarly constituted mass of wrought iron, is subjected to the action of the "hammer" or "rolls," the contained "cinder" endeavors to escape from its entangling alliance with the crystals of the iron, and in so doing, each particle thereof is driven into some line of least resistance, which is always finally located in a plane at right angles to the direction of the force acting upon the metal. In other words, if the "bloom" is rolled or forged into a rod or bar, the metal will be acted upon in two directions at right angles to each other,* and its compound crystals will be compressed in directions normal to the exterior surfaces of the bar, and at the same time extended in the direction of its length. Thus the ends of adjacent crystals are forced towards each other, and the intervening "cinder" is compelled to move at right angles to the axis of the bar, and to unite with the films or threads of "cinder" which have become established in parallel lines of least resistance along the flanks of the compound crystals, and at right angles to the direction of the force acting upon the bar.

Fig. 1 is intended to illustrate on an exaggerated scale this arrangement of the elongated compound crystals of iron with intervening films or threads of "cinder," the light spaces representing the iron crystals and the dark lines the "cinder"—the force of compression being supposed to act upon the bar in the direction of the arrow.

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* In forging a bar it is the usual practice to turn it about its axis through an angle of 90° between the blows (or series of blows) of the hammer; and in rolling a bar it is commonly turned through the same angle between "passes" through the rolls.

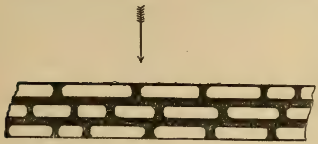
FIG. 1.

Fig. 2 illustrates a method of showing by experiment the character of the structural difference between a bar of wrought iron and one of a homogeneous material such as low steel. In this figure, let *A* be a vertical section of a cylinder provided with an accurately fitted plunger *P*. The space *B* below this plunger we will suppose to be filled with small fragments of lead of irregular dimensions, whose surfaces are covered with a coating of oxide of lead.

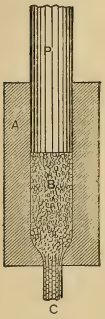

FIG. 2.

If, now, sufficient force is applied to the plunger *P*, the lead will be forced out of the hole in the lower end of the cylinder in the form of a rod *C*, and every fragment of lead will have become more or less elongated, but will be prevented from actual metallic contact with adjacent fragments by a film or thread of oxide of lead. In this experiment, the elongated fragments of lead correspond to the extended compound crystals of iron before named, and the oxide of lead occupies the same relative position in the rod of lead as the "cinder" in a bar of wrought iron. If now, in place of the fragments of lead, we place in the space *B* a solid mass of that metal, then, on applying adequate force to the plunger *P*, there will be forced through the hole in the bottom of the cylinder a rod of lead, whose structural difference from the former rod, made from the oxide-covered fragments, is closely allied to that subsisting between a bar of low steel, and one made of the "cinder"-coated compound crystals of wrought iron.

The direct consequence of the elongation of its compound crystals and the effort of the intervening "cinder" to escape in the direction of least resistance while the wrought-iron "bloom" is being forged or rolled as before described, is the establishment of that structural peculiarity in the resulting bar known as "fibre," which is one of the most conspicuous features of wrought iron, and one not found in any other variety of ferruginous materials.

When any of the films or threads of "cinder" in a bar of wrought iron are so large as to be distinctly visible on its surface to the unassisted eye, they are called " sand seams " or " cinder cracks."

If its compound crystals are nearly pure iron, the bar can be readily bent cold without fracture, and, if pulled asunder by a gradually augmented force, its fibrous texture is at once evident; but in case the compound crystals have chemically combined with them some substance, such as phosphorus or silicon, which tends to diminish both the cohesive attraction between the ultimate crystals of which they are composed and the mutual attraction of the compound crystals, then the bar cannot be easily bent cold without rupture, and is said to have a " crystalline fracture." Notwithstanding this appearance, however, the mechanical structure of the bar is the same as before; that is to say, the " cinder " and elongated compound crystals are still arranged in lines parallel with the axis of the bar, although it is quite probable that the average length of the compound crystals may be much less than in the case of the bar first described.

Whenever a " bloom " is subjected to a force of compression always acting perpendicularly to the same plane, as is the case when it is rolled into a " sheet " or " plate," its compound crystals and accompanying " cinder " are each flattened and extended parallel with that plane, and the resulting " sheet " or " plate " has more of a laminated than of a fibrous structure, being built up of a number of leaves or strata of iron separated from each other by films of " cinder," which, when unduly thick at any point, cause defects in the plate that are called " blisters."

The foregoing discussion of the structural difference existing between a bar of wrought iron and one of homogeneous iron (often called " low steel ") naturally brings to mind an important practical question relative to the employment of wrought iron in construction which is often asked; viz., Will a given sample of wrought iron having a decidedly fibrous texture become crystalline under the operation of a continued repetition of violent strains or shocks? Doubtless many persons of large and varied experience will unhesitatingly answer this question in the affirmative. The sailor who sees his chain cable (known to have been made of carefully selected, thoroughly worked, and honestly tested fibrous iron,) snap short, has no doubt about the metal having become crystalline owing to lapse of time and rough usage. The practical farmer, as he examines a broken trace or plow chain, is firmly of the opinion that the iron thereof had become crystalline by use. The railway passenger who has fortunately escaped serious injury from an accident caused by a broken axle, is usually ready to testify, with emphasized confidence, that "the iron of the axle was crystalline, and entirely unfit for the purpose for which it was used." A modern fiddle-string bridge goes down under a passing train, plunging a whole community in mourning and sending a thrill of shivering horror through the land—among the various theories advanced to disguise the utter want of sufficient intelligently distributed material in the structure, is sure to be found that of the crystallization of the iron employed.

But let us return to our question. Can a bar of wrought iron of a pronounced fibrous structure be ruptured so as to exhibit a crystalline fracture? I answer, yes,—in two ways. 1st. By a sudden application of a force of extension—commonly called a "jerk." 2d. By a prolonged repetition of a force of compression—sometimes called a "jar."

The first method of rupture may be said to consist of a transverse division of the compound crystals of the bar, as distinguished from a sliding of their interlocking flanks upon each other, as is the case when the rupture presents a fibrous appearance. I have often seen crystalline fractures produced in truly fibrous iron. In the manufacture of iron rails (now nearly an extinct industry), it was always considered desirable that they should be of a hard and crystalline texture as to their tops or "heads," but soft and fibrous in their bottoms or "flanges"; but however perfectly this distribution of metal was made, it was always possible to break a rail so as to show a crystalline fracture in its "flange." This was accomplished by making a slight "nick" across the flange (to determine the point of fracture), and placing the rail ("flange" down) in the "straightening press," on supports placed a short distance on either side of the "nick," and then putting in the "gag" "*heavy*," just over it: the result was almost always a crystalline fracture in the "flange"—in short, the elongated compound crystals were "jerked" asunder. But, if the points supporting the rail were placed further apart, and the rail given an opportunity to yield considerably between them, then, if the "gag" was put in "*light*," a number of times in succession, the fracture of the "flange" would be sure to exhibit a fibrous texture, due to the fact that sufficient time had been given to break up the films of "cinder" along the flanks of the compound crystals and destroy their transverse cohesion, thus permitting them to slide apart, and exhibit the appearance of disrupted fibres.

We are indebted to a not uncommon accident to which the hammer bars of a peculiar type of steam-hammer are liable, for an excellent illustration of the second method of producing a crystalline fracture in fibrous iron, the result of the repeated action of a percussive force of compression. In Fig. 3 is represented at *A* the bar of such a steam hammer. As has been before stated, there exist, in a bar of fibrous iron, films of "cinder" between the ends of its elongated compound crystals (as shown exaggerated in Fig. 1). These, from the nature of their formative process, cannot possibly be of uniform thickness. This, considered in connection with the fact that the greatest force of the percussive action per unit of area of any cross section of the hammer bar is exerted upon a section made by a plane cutting the bar at right angles immediately above its head, justifies the belief that at, or near, this point, fracture would be most likely to occur. It is also evident that the percussive action of the hammer would have more destructive effect upon thick than upon thin films of "cinder"; while, at the same time, the force of cohesion between the ends of adjacent compound crystals will be diminished in some inverse proportion to the thickness of the films of "cinder" between them. It therefore seems exceedingly probable that the fracture due to continued percussion will take place, if not in the plane above named, yet in one very near to it, in which the "cinder" films chance to be of greater thickness than those in that plane; and, as a matter of fact, fractures in such bars are usually within a few inches of the point where the bar enters its head, as at *G*, *H*, Fig. 3.

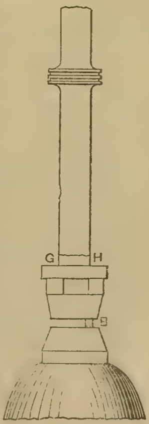

FIG. 3.

The particular point in the circumference of such a hammer bar where the imminent fracture first appears is often determined by the manual peculiarity of the "hammer-man." A left-handed man will incline his work to the left, and a man who is right-handed will be likely to use the right side of the anvil more than the left. In this latter case the work *B*, Fig. 3, will tend (whenever it is in the position shown) to produce a tensile strain at the point *G*, which, as the work is shifted to the centre or occasionally to the left side of the anvil, becomes a compressive strain. We should therefore expect (as is, in fact, the case) that the initial manifestation of the fracture would be found at that point, and that it would gradually extend towards *H*, until the bar was finally "jarred" asunder. This separation would take place through films of "cinder" between the ends of the elongated compound crystals of the bar, thus exposing those ends, and exhibiting what is called a crystalline fracture.

The belief in this so-called crystallization of wrought iron, as the result of prolonged use, is, I think, altogether a mistake; and I am clearly of the opinion that the crystallization observed in the case of any particular fracture existed just as we see it at the time the metal was given the shape in which it was ruptured. After a bar of distinctly fibrous wrought iron has been subjected to multitudes of sudden "jerks" of extension or "jars" of percussive compression, the "cinder" in some cross section of it (in which this impurity is slightly thicker than elsewhere) gets broken up, cohesion is destroyed, and the bar breaks with a crystalline fracture.

I have had a specimen prepared for the purpose of making the foregoing explanation of the apparent crystallization of fibrous iron more evident. It is a short piece of a square bar of wrought iron. One end is decidedly crystalline in its fracture, showing distinctly that the bar was originally built up of five flat bars. The other end is, for more than one-half of its area, as decidedly fibrous as wrought iron can well be; and this end would have been uniformly fibrous in appearance had the workman who made the specimen exercised the requisite care. Thus, in a sample not over two inches in length, we have an instance of a fracture which most observers would call very bad, and another which as certainly would be called good.

It is a well-known fact that wrought iron is improved in strength by repeated working. This may be accounted for thus:—in the initial heating and shaping of the metal, its crystals were left with a comparatively thick film of "cinder" between them; but, by each successive reworking, the crystals of metal are driven into closer order, some of the intervening "cinder" is expelled, and what remains is very much reduced in thickness, so that the cohesive attraction (whatever that may be) between these crystals, having less space to act through, acts with augmented intensity. It is well to remember, when we speak of "less space" in a matter of this kind, that we are dealing with a very small quantity indeed—one that is a near neighbor to the infinitesimal.

Time passes, and though I could fill the fleeting hour with talk about iron, yet in this lecture, as in the field of mechanical construction, it is now fitting that iron should give place to steel.

What is steel? To the many answers to this frequently asked question, I may perhaps venture to add this one more, namely, that steel is iron freed from mechanically mixed impurities (such as "cinder") by a melting process, during which it has combined with it chemically a small percentage (not large enough to prevent the metal being forged or rolled) of other impurities, introduced for the purpose of modifying its strength, hardness, elasticity, or ductility, in such degree as to adapt it to the particular use to which it is to be applied. In short, while wrought iron is iron having (as the legitimate result of the methods employed in its manufacture) its impurities mechanically mixed, steel is iron having (as the result of the adoption of appropriate manufacturing processes) its impurities chemically combined.

A great deal of the difficulty of correctly fixing the *status* of any given sample of ferruginous material may be eliminated by recognizing the fact, that what is called wrought iron is not really iron, and that the only way in which *pure iron* can be obtained is by electrolysis; a process which is, I need hardly say, commercially impossible for all practical purposes in the present state of our technical knowledge.

I cannot on this occasion describe at length the various processes employed for the manufacture of steel, but will call your attention to certain practical details which are of especial interest and importance.

If we break a large ingot of mild steel (say of 12″ to 15″ square) at right angles to its length, and examine the fracture, we shall find at a distance of from three-quarters of an inch to two inches from its sides, a collection of cavities or "blow holes" (as they are commonly called), which are of an irregular spheroidal form, and of variable size, the largest seldom exceeding one-half an inch in diameter. These holes are separated from each other by partition walls of irregular thickness, and in most instances are coated on their interior surfaces with films of a more or less iridescent oxide of iron. Fig. 4 will serve to give an idea of such a fracture as has been described.

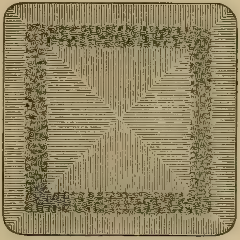

FIG. 4.

There has been a great deal of speculation as to the origin of this array of cavities. Some have supposed that they were caused by gases dissolved in the fluid steel (very much as carbonic acid is dissolved in water), and that at the moment of solidification these gases separated out, and arranged themselves in the order in which they are found—that of a hollow square (in the case of a square ingot) whose sides are parallel with those of the ingot mould. Others have asserted that oxide of iron is present in the fluid metal, and that this being reduced by the carbon in the steel, carbonic oxide, carbonic acid, or both are set free, which being unable to escape before the steel solidifies, produces the aggregation of cavities we are considering. This theory may be in a measure true in the case of steel containing oxide of iron, but we know that good metal does not contain oxygen, and if the holes were in any great degree due to the reaction mentioned, they would be likely to be evenly distributed through the mass of the ingot, and not confined, as is the fact, to a well-defined zone.

Other suggestions involving more or less occult, hypothetical, and ingenious chemical and molecular considerations have been made; but all fail to account satisfactorily for the symmetrical arrangement of the holes observed.

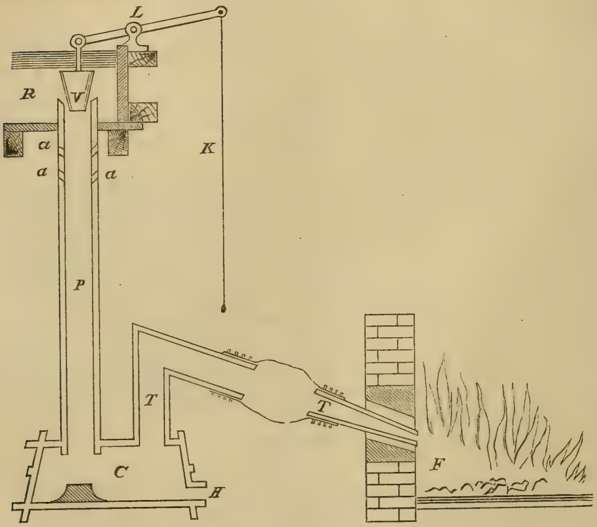

FIG. 5.

My own explanation of the formation and peculiar distribution of these cavities is a purely mechanical one, which I will now endeavor to make clear.

It is a well-known fact that a vertical stream of any liquid descending freely through the atmosphere drags along with it, by frictional contact, a notable quantity of the air or of any other gas that may be in its immediate vicinity. This fact was many years since taken advantage of in the construction of the blowing apparatus called the "tromp," used for furnishing the blast for the forges of Catalonia.

This apparatus consists of a vertical pipe *P* (usually of wood), whose height is determined by that of the head of water at the locality of the forge; the upper end of this pipe passes through the bottom of the wooden race-way *R* (Fig. 5), and is closed or opened by the movable conical plug or valve *V*. Below the bottom of the race-way *R* there are several inclined apertures *a,a,a*, made in the sides of the pipe *P*. These are for the purpose of admitting air, which, when the valve *V* is raised, is drawn in by the descending column of water, and mixing therewith, is carried downward and discharged thereby into a receiving chamber *C*. Here a separation of the air and water takes place, the former passing through the tuyère pipe *T*, *T* to the forge-fire *F*, and the latter escaping from the receiving chamber through a hole in its side at *H*. The volume and pressure of the blast supplied can be regulated within certain limits by raising or lowering the valve *V*, by means of the cord *K*, acting through the lever *L*.

Over twenty years since (1863), I employed (in the laboratory of the experimental Bessemer steel works at Wyandotte, Michigan) the principle of the mechanism described for supplying blast for a table blow-pipe. The apparatus for this purpose consisted of an ordinary three-necked Woolf bottle *B* (Fig. 6) of about a half-gallon capacity, to the middle neck of which was adapted a cork through which was passed the stem of a small funnel *F*, which reached nearly to the bottom of the bottle. To the right-hand neck of the bottle *B* was fitted the discharge syphon *S*. The left-hand neck of the bottle *B* had fitted to it a bent glass tube *T*, to whose horizontal end was attached a rubber tube for conveying the air to the blow-pipe. To put the apparatus in operation, a stream of water was discharged from a jet-pipe *J* into the top of the stem of the funnel *F*. The diameter of this stream was slightly less than the internal diameter of the tube of the funnel, and could be regulated as regards its volume and velocity by a suitable cock *C*. As the stream of water from the jet-pipe *J* descends the tube of the funnel *F*, it drags along with it by frictional contact a very considerable volume of air, which, on reaching the bottom of the bottle *B*, separates from the water and passes to the blowpipe through the rubber tube before named, the water finding an exit through the discharge syphon *S*.

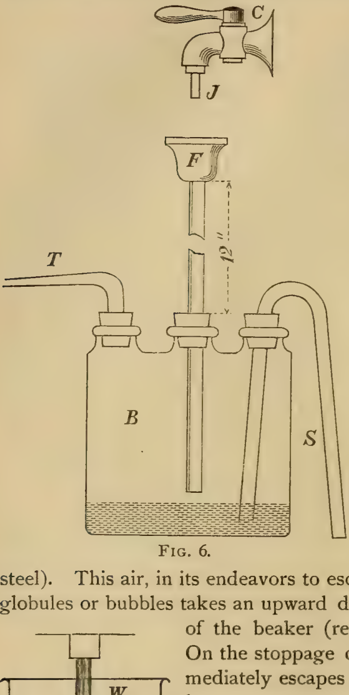

FIG. 6.

Now let us see how the action of the "tromp" and the apparatus just described is concerned in the casting of an ingot of steel.

Let the beaker *B* (Fig. 7) represent an ingot mould, and the descending stream of water *W*, the stream of liquid steel;—it will be seen that the stream *W* carries with it a large volume of air into the water (for illustrative purposes regarded as liquid steel). This air, in its endeavors to escape, turns, and in the form of globules or bubbles takes an upward direction parallel with the sides of the beaker (representing the ingot mould). On the stoppage of the stream, all this air immediately escapes from the water, leaving it as homogeneous as water usually is; but, if during the filling of the beaker the water therein was rapidly frozen (the progress of the congelation being from the sides towards the centre), it is evident that the ascending bubbles of air would be entangled in the ice as it formed, and we should have as a final result a vesicular mass or ingot of ice, quite similar as regards its method of formation to the ordinary ingot of steel.

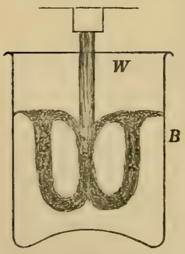

FIG. 7.

Another illustration may make the formation of vesicles in steel ingots still more clear. If in place of water in the preceding experiment we substitute mucilage, or any other fluid of similar consistency, we approach much nearer to the actual conditions which exist in the casting of a steel ingot; for the steel as ordinarily melted is never as fluid as water, but approximates more nearly in mobility to the character of mucilage. As, then, the stream of mucilage descends, it will be observed that it carries with it air in the same manner as the stream of water; but that owing to the viscosity of the fluid, the air bubbles rise through it more slowly and escape with greater difficulty, and that some of them, as they approach the surface, are again dragged down by the central descending current. Hence there is a much larger collection of bubbles of air in the mucilage than there was in the water, and, consequently, if the mucilage was solidified at the moment the descending stream was stopped, we should have a much more vesicular mass than in the case of the frozen water in the last experiment.

In comparing the foregoing experimental illustrations with the actual conditions which exist during the casting of an ingot of steel, we find an ingot mould of cast iron (corresponding to the beaker), which is filled by a rapidly descending stream of molten steel (corresponding to the water or mucilage), not as liquid as water, but more nearly of the consistency of mucilage. We also find that this stream carries into the imperfectly fluid mass of steel which rapidly fills the ingot mould a large volume of air, which attempts to rise and escape from the rapidly cooling and solidifying mass of metal in precisely the same way as the bubbles of air endeavored to escape from the water and mucilage in our two illustrative experiments.

But we find another condition present in the case of the molten steel that did not exist in either experiment; viz., the fact of a high temperature in the fluid metal. If we examine this condition, we shall readily discover that it has a very important influence both on the size and number of the vesicles included in the ingot of steel; for it is a well-known fact that dry air, for each 480° F. increment of temperature, increases its bulk by the amount of its original volume. Now, as the fluid steel is at least of the temperature of 3300° F., dry air introduced in the manner illustrated would be so expanded as to occupy seven times the space in the ingot that it did in the atmosphere.

There is, however, yet another fact that tends still further to augment both the size and number of the so-called "blow holes" that we are considering. It is a well-known practical condition that the air in the immediate vicinity of steel-casting pits is far from being dry. The large quantity of water used for cooling ingot moulds, and for other purposes, keeps the atmosphere surrounding both casting-ladle and ingot-mould in a very moist state, and it is certain that all such vapor-laden air carried into the molten steel would increase in volume for a given increment of temperature very much more than dry air, and would therefore correspondingly increase the size and number of the "blow holes." Furthermore, this vapor of water does not act to this end altogether through its expansion under the influence of heat, for some, if not all of it, is decomposed by the high temperature, and its oxygen, together with that of the accompanying air, is absorbed by the walls of the cavities. This produces the iridescence observed, and leaves in the "blow holes" an atmosphere composed mainly of hydrogen and nitrogen; and it is not at all improbable that in many cases this decomposition of the watery vapor did not take place until the steel was so far solidified as to prevent the walls of the cavities yielding to any great extent, and, under such circumstances, the gases named would be under a very considerable tension.

This view is confirmed by the investigations of Prof. F. C. G. Müller of Brandenburg, who found that the mean composition of the gases in the "blow holes" was

Hydrogen, ...	79	per cent.
Nitrogen, ...	19	"
Carbonic oxide, ...	2	"
	100	"

and that their average pressure was 120 pounds per square inch.

It is of course possible that some of the gases found in the "blow holes" of Bessemer steel ingots may have found lodgment in the steel during the process of "conversion," more especially when steam is admitted with the blast for the purpose of keeping down the temperature of a "hot blow." In this case the steam would certainly be decomposed, and some of the residual hydrogen might remain entangled in the metal; although doubtless much the larger portion owing to its great levity, would escape during the pouring of the steel from the "converter" into the "casting ladle." In the case of open-hearth steel, however, there would be no such reason for the presence of hydrogen.

The foregoing explanation of the presence and methodical arrangement of the cavities or "blow holes" in steel ingots, and the character of the gases found in them, is, I think, sufficient to account for all the facts observed. The assertion which has often been made (as a sufficient explanation), that "the gases are occluded in the steel," deserves to rank with the pompous declaration of a village pedagogue that a total eclipse of the sun which was terrifying his neighbors was "only a phenomenon." "Words of learned length and thundering sound" discourage rather than stimulate the inquiring mind.

I now desire to call your attention to a species of cavity much too frequently found in forgings of steel, that does not originate in the manner already described.

If a large cold ingot is put into a too highly heated furnace, its exterior surface will expand so much faster than the parts at or near its axis, as to strain the metal in the interior of the ingot beyond its elastic limit, and oftentimes actually rupture its central continuity, as is shown at *A*, Fig. 8. Such a breach may in some cases have a diameter equal to half that of the ingot.

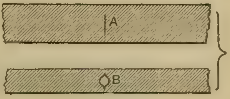

FIG. 8.

An ingot thus internally fractured, if hammered or rolled down to a smaller section, will have a cavity developed in the centre of its mass, as shown at *B*; and unless the existence of this cavity is discovered, serious difficulty may result from the use of such a forging as a part of any mechanism. It is not at all impossible for a number of such cavities to be formed in the same ingot, if the heating be sufficiently rapid, in which case the initial rupture would occur at *A*, Fig. 9, at or near the centre of the ingot; a second and third fracture would then take place almost simultaneously at *B*,*B*, about half way between *A* and the two ends of the ingot; and, finally, a third set of internal breaks may be formed at the points *C*,*C*,*C*,*C*, thus dividing the ingot into eight nearly equal parts of solid metal. The diameters of the several ruptures would vary in the following order, viz: That at *A* would be the largest, those at *B*,*B*, somewhat less, and those at *C*,*C*,*C*,*C*, least of all. Such an ingot—if the internal ruptures were not too large—might be forged into a propeller shaft and actually

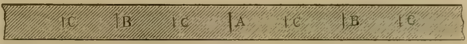

FIG. 9.

put into a vessel, without the defects being discovered until it was twisted asunder on its first voyage.

Such possibilities of carelessness in the manufacture of heavy forgings of steel as I have described make it highly desirable that some method be devised to detect the presence of such internal ruptures before much time and labor have been expended upon the forging, and also to prove its soundness when completed. About twenty years ago, a plan for this purpose was proposed by Mr. S. M. Saxby, R. N., and some extended experiments to test its practical value were made by direction of the Admiralty; but, although the early investigations were very promising, the method has not become established as one of the acknowledged reliable means of testing forgings of iron or steel.*

It is possible that some method of electrical examination may be found of service in testing the soundness of forgings, and I will venture to suggest the following:—

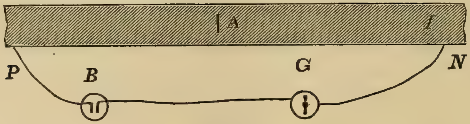

FIG. 10.

Let *A*, Fig. 10, be an internal rupture in the ingot *I*, to the extremities of which are connected the wires *P*, *M*, of the battery *B*, having in the circuit a galvanometer *G*. Under these conditions the galvanometer needle will be deflected a certain amount, which is a function of the strength of the current and the resistance of the circuit; and if by any means the resistance of the circuit is diminished, the deflection of the needle of the galvanometer will be increased. For instance, if, in the proposed apparatus, the wire *N* be moved towards the left, for each inch of movement there will be a corresponding increase of deflection of the needle of the galvanometer; but when the wire passes a point opposite the rupture *A*, the law of the increase of deflection may be found to change, and to indicate the presence of an internal breach of continuity in the ingot or forging under examination. I have had no opportunity to test this method, but make the suggestion in the hope that some one having the means and leisure will give it a thorough examination, and that it, or some modification of it, may be found of practical value.

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* This method is described in an article which was first printed in *The Engineer*, Dec. 7th, 1867, reprinted in *Engineering*, Dec. 13th, 1867, and subsequently embodied in Kohn's Treatise on Iron and Steel, 1869.

Thus far I have spoken only of the transverse internal rupture of steel ingots in consequence of too rapid heating; but longitudinal internal ruptures can be, and often are, produced by the same cause.

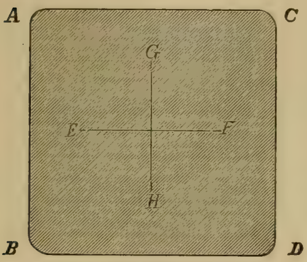

FIG. 11.

In Fig. 11, let *ABCD* represent a cross section of a steel ingot. If too rapidly heated, the opposing sides *AB* and *CD* will expand so much faster than the centre, that an internal rupture *EF* may be formed; and the expansion of the sides *AC* and *BD* may in like manner develop a similar rupture *GH*, located in a plane at or nearly at right angles with that already named.

Such ruptures, though generally situated in planes at or nearly at right angles to each other, are not confined to planes located as shown in Fig. 11, for the planes of rupture may coincide with the diagonal planes of the ingot, or may occupy any position between such diagonal planes and that shown in the figure. In fact, their position is fixed by the resultant action of two forces, due to the expansion of the exterior of the ingot by the sudden heating, modified by the powerful internal strains existing in the cold ingot tending to separate the metal at its centre. These strains were established at the time the metal originally solidified in the ingot mould, and are occasioned by the outside of the ingot cooling, while its interior is either fluid or plastic; and as the whole mass becomes cold, its interior, by the force of cooling contraction, is strained in many cases beyond its limit of elasticity, which limit may with propriety be defined as the beginning of rupture. An ingot of steel thus internally strained would require but the small addition to the tension which a too rapid heating of its outside would furnish, to produce such interior longitudinal fractures as have been described. The extent of the influence of such internal strains in all stages of the manufacture of steel is very irregular and uncertain, and this fact makes them all the more worthy of consideration in all cases in which steel is to be subjected to uses which involve the application of sudden and violent shocks.

Of the effect of such strains in steel used for the construction of cannon, Col. Eardley Maitland, R. A. Assoc. Inst. C. E., Superintendent of the Royal Gun Factory at Woolwich, in a recent paper said: "On a review of the results obtained, the author, having seen so many instances of the fracture of steel, sometimes spontaneous and sometimes under stresses quite inadequate to produce the result, was of the opinion that internal strain was the gun-maker's worst enemy, and that it was a question of great moment whether it was worth while to incur the risk of setting up such strain by oil-hardening."

It is not at all improbable that in many instances (especially in the case of steel having considerable hardness) ingots may be ruptured internally both transversely and longitudinally, thus aggravating the evil of either single species of rupture. If such an ingot were forged into a heavy crank pin, its whole interior would be permeated with most irregular and intricate imperfections, though at the same time the ends and cylindrical surface of the forging might have every appearance of soundness.

As a practical illustration of the great importance of the subject we have been considering, I cannot do better than quote the description of a defective forging given by Professor Thomas Egleston in Transactions American Society of Mechanical Engineers, Vol. VII., p. 263. He says: "I have recently had occasion to examine a forged crank pin made with great care from the best of open-hearth steel. It was rough turned to 16⅝ inches. To ascertain its quality in the centre, an inch and a half hole was bored through it. This hole revealed such a number of cracks and cavities that the hole was increased to four inches, in the hopes of cutting them out. Defects of considerable size were still found. The pin was then sawn in two [planed apart longitudinally], where single horizontal cracks 10 inches in diameter and ⅜ inch wide were found, and inclined ones 7½ inches long, in which were cavities ½ an inch wide, to say nothing of defects of minor importance. None of these defects would have been revealed but for the forethought of examining the centre of the piece. If it had been used without this examination, it would have produced great disaster."

I also have had an opportunity of examining the forging described by Professor Egleston, and was told that it was made by one of the oldest and most experienced manufacturers of such work in this country. My experience teaches me that such defective forgings are far more common than the managers of our steel works and forges are disposed to admit or even believe.

It is a common opinion that one of the reasons why steel forgings are often found hollow in their interior is the failure to work them under a sufficiently heavy hammer; but no hammer, not even "the hammer of Thor," can do more than aggravate the evil of internal ruptures in ingots of steel.

But let us now turn from this long digression relative to internal ruptures in ingots and forgings, and resume the consideration of the matter of "blow holes" in steel ingots. Having endeavored to explain and illustrate what I regard as the principal cause of the formation of such "blow holes," allow me now to examine some of the consequences of their presence.

The first result of hammering or rolling a vesicular ingot will be nearly to close the "blow holes." I say nearly close advisedly; for although the vesicles may become divided, and be made to change their shape and vary their capacity, even to the extent of becoming microscopically small, they never wholly disappear.

As the "blow holes" are reduced in diameter, the contained gases are therefore subjected to a very great reduction of volume, and consequent increase of pressure in the inverse proportion to such reduction. For instance, if the initial pressure of the gases in the "blow holes" was 120 pounds per square inch (as observed by Professor Müller), and these cavities were, by hammer or rolls, reduced to one-tenth of their original diameter, their capacities would be but one-thousandth as great as at first, and therefore the pressure of the contained gases would be $120 \times 1000 = 120{,}000$ pounds per square inch. But, in estimating the value of this pressure to produce rupture, we must bear in mind that it acts only upon an area one one-hundredth as great as it did originally.

Now let us suppose that an article made from steel in the above described condition is subjected to a heat of 1000° F. (a dull red). In that case, the gases inclosed in the cavities of the steel will, by reason of their tendency to expand, exert three times the pressure that they did when cold, and if such pressure is symmetrically distributed (a not very likely circumstance), the article will when cold retain its original contour; but, if there is more internal pressure upon one side of the object when heated than upon its opposite, distortion will naturally result, a thing not at all uncommon in annealing articles of steel. Thus we see that throughout a bar or other forging made from a vesicular ingot of steel there may exist a vast number of magazines of force, of great though very variable intensity, but quite sufficient to aid powerfully any external strain which tends to break the bar.

Now let us see what would be the result if the "blow holes" were without gaseous contents. Were it possible to find an ingot whose "blow holes" were absolutely empty, when it was worked, the sides of the holes would come together, but, owing to the low temperature, they would not weld. At the same time, the holes would become elongated and be made to approach each other transversely, and, in fact, would finally develop into "seams" of a variable length and depth, as they chanced to originate from large or small holes. Such a state of affairs, as may be readily understood, could have very little influence upon the ultimate ability of the bar to resist a tensile strain; but, if such a bar were subjected to compression, it is easy to see that it would yield unequally, and much sooner on the side having the greater number of such seams.

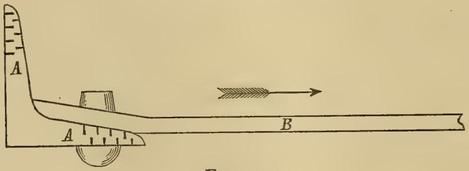

FIG. 12.

But it is when such a bar is subjected to a transverse strain, tending to pull it apart in a direction perpendicular to that in which it has been worked, that these seams are the most injurious. Take, for example, an "angle iron" made from such an ingot: it is not at all improbable that the "seams" would be so arranged in the flanges (as at *A*, *A*, Fig. 12) as nearly to separate them into a series of rods held together transversely by occasional ligatures of metal. Now, if such a bar be punched or drilled through the "seams," and another bar *B* be riveted to it (as shown in the figure) and subjected to a strain in the direction of the arrow, it is self-evident that the "angle bar" would be much more likely to be pulled apart transversely through the rivet-hole than if it were made of a homogeneous material.

I think I have said enough about "blow holes" to convince any one that under the ordinary methods of manufacture they are very likely to occur, and that they are exceedingly objectionable things to have in the metal; and now let us examine the efficiency of some of the methods that have been devised to mitigate the evil of their presence.

Some years since, the late Sir Joseph Whitworth proposed and practically carried out a mechanical process of compressing steel in the ingot mould while it was still fluid or plastic, his intention being to destroy the "blow holes" by the action of the enormous pressure employed. He certainly succeeded in turning out from his works most admirable products in steel; but I have always had a feeling that the high character of his forgings was due more, much more in fact, to the chemical constitution of the metal, and its having been skillfully heated and carefully worked, than to any qualities resulting from its having been compressed while in a fluid state.

Let us examine this matter a little more closely. Suppose *I*, Fig. 13, to be a vertical section of an ingot mould filled with fluid steel *S*, (having more or less "blow holes" distributed through its mass, as indicated by the small circles,) which may be forcibly acted upon by the plunger *P*. Now, as fluids under pressure act equally in all directions, it is evident that all the "blow holes" will be reduced in size, and also that the tension of their contained gases will be increased in the inverse proportion to their reduction in volume; but it is not so clear that there is any action that will cause their removal from the steel altogether.

The same reasoning applies to all systems of vertical compression, whether by the action of carbonic acid, as employed by Herr Krupp, or by high-pressure steam, as at one time used in this country.

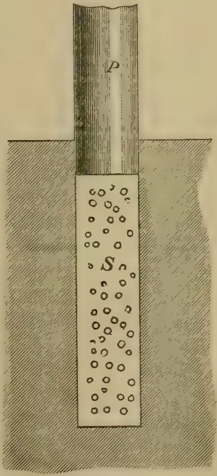

FIG. 13.

Some system of closing the top of the mould and producing a vacuum above the steel would seem to be a more rational mechanical method of removing the "blow holes," than any system of compression; for, as the pressure upon the steel was reduced, the gases in the "blow holes" would expand, and their augmented levity would cause them to escape from the fluid steel with greater rapidity than is possible under any other condition. But, after all, the simplest way of getting rid of the "blow holes" in steel is so to treat the metal before it is run into the ingot mould, that its capacity for heat is increased to such a degree that it will remain fluid long enough to permit the gas-filled "blow holes" to escape as freely as bubbles from water.

This suggestion brings me naturally to a consideration of the "Mitis process"; but before entering upon it, I desire to speak briefly of some points relating to the very important practical operation of hardening and tempering steel. As regards the latter process, it would be for the advantage of all who use tools of steel, if the subject could be disposed of in as few words as comprised a somewhat famous account of snakes in Ireland, which simply declared that "there are no snakes in Ireland." I wish it were possible to say that there is no such thing as the present practice of tempering steel; for I am firmly of the opinion that much better results can be attained in its use by simply hardening it at such a temperature as by practice with the particular steel used is found most satisfactory, and omitting altogether the lawless and uncertain operation known among mechanics as "drawing the temper."

I have in my possession an admirable illustration of the possibilities of the methods suggested, in the shape of a razor made from the first Bessemer steel produced in this country. This steel, judged by the ordinary standards for "razor steel," would be considered altogether too soft for the purpose; but, nevertheless, by hardening it as much as possible, and leaving it in that condition, it made so satisfactory a razor that my father shaved himself with it for fifteen years.

I have already referred to the views of Colonel Maitland relative to hardening steel, and feel sure that the practical experience of all who have had the most to do with that operation leads to a similar conclusion.

In this connection it will be instructive to quote some of the remarks made by acknowledged experts during the discussion of a paper communicated to the American Society of Mechanical Engineers by Professor John E. Sweet ("The Unexpected which often Happens"; see Transactions American Society of Mechanical Engineers, Vol. VII., pages 156 to 160). In this discussion, Mr. Henry R. Towne, President Yale & Towne Manf. Co., speaks of numerous unsuccessful attempts to harden certain castings of steel, and states that it was finally discovered "that the steel hardened beautifully *inside*, but that there was on the outside a thin skin of metal, about three to four hundredths of an inch in thickness, which, except by the cyanide process, did not harden at all. In all of the castings there was perfect hardening under this skin; and finally, the moral of this is that we should *look below the surface*"—a moral, I will add, which should not be forgotten by those who hope to succeed in the employment of steel. In the same discussion, Mr. Geo. M. Bond, Superintendent Gauge Department, Pratt & Whitney Manf. Co., said: "We find in our experience in making taps and reamers, that in case the steel has been over-annealed and has thus been decarbonized, the hardening does not take effect except under the surface, so that frequently, taps which appear to be soft, if turned again will harden perfectly. I think perhaps the castings referred to by Mr. Towne may have been over-annealed, and in that way a percentage of the carbon eliminated so that the hardening would not take effect upon the outside surface." In the same discussion Mr. Bond further remarks: "We had occasion to make a set of gauges in which the sizes were all two ten-thousandths of an inch larger than the nominal sizes, and five days after the gauges were finished, one of them suddenly gave way in the centre, a crack extending around it spirally, but not so as to injure the ends of the gauge. Out of curiosity, I thought that I would measure the uninjured parts to see if any change had come in the diameter, and I found at both ends the diameter had enlarged forty divisions of the micrometer, which is equal to six ten-thousandths of an inch, and which, as magnified, represented a space to the eye of about three-sixteenths of an inch under the microscope. This shows, I think, that if steel hardens at all, the internal strain must be something tremendous. This will also explain why steel, in being hardened through the centre, has a tendency to shorten under certain conditions."

Professor William A. Rogers, Assistant Professor of Astronomy, Harvard University, said: "The unexpected has *always* happened to me in this matter of obtaining hardened steel which has a homogeneous temper throughout the entire mass. The nearest approach to an even temper which I have ever been able to obtain has been at the works of Miller, Metcalf & Co., of Pittsburgh, and of Brown & Sharpe, of Providence. A short time since I asked the latter firm to set a price upon a hollow steel cylinder six inches in diameter, three feet in length, having walls half an inch in thickness, hardened and ground on the outside only. The price which was set—from $300 to $500 without guarantee against flaws—may be taken as the estimate of the extreme uncertainty always attending any difficult case of tempering held by those who have a full comprehension of the difficulty of the problem.

"The difficulty of giving a homogeneous temper to a large mass of metal is so great, according to my experience, that it is never perfectly done. The test which I apply as the gauge of an even temper is a very severe one. If all the lines ruled upon a highly polished bar of tempered steel have the same appearance, the temper of the graduated surface is good. I have, however, never yet seen a set of graduations in which the diamond has with a constant pressure cut all the lines to the same depth. The diamond acting upon this polished surface detects the lack of homogeneity in the most perfect manner. If there is any person in this country, or in the world for that matter, who can temper a bar of steel three feet in length and for a depth of even a quarter of an inch, at any price, I should be glad to make his acquaintance."

Mr. George Ede, in that chapter of his work on "The Management of Steel" (edition of 1866) descriptive of the method of "toughening of steel in oil," as at that time practised "in the Gun Factories' department of Her Majesty's Royal Arsenal, Woolwich," says, relative to hardening solid steel shot: "Thick lumps of highly carbonized steel, whether hardened in oil or pure water, or water with a film of oil upon its surface, cannot be hardened without becoming fractured either internally or externally." In this matter of hardening steel, the value of the "personal equation" of the workman is all important. It is not uncommon to find a practical mechanic who usually has good success in the use of a certain kind of steel with which his neighbors, equally skillful perhaps in other matters, can do nothing. So often have I encountered this fact, that I am inclined to believe that if a person in pursuit of information as to the proper quality of steel to use for any given article should travel through this land and obtain the honest opinion of all who were making the article in question, that "the last state of that man would be worse than the first"; for the chances are that every person consulted would have an opinion differing from those of his fellow-craftsmen, and although when our traveller started on his search for technical wisdom he was positive that he knew nothing, he could not rejoice in even that negative certainty when he returned. In the present state of our knowledge, there is no recognized uniform scientific method of hardening and tempering steel: all we have is a tentative art, as crude in its development as it is obscure in its origin.

And now let me crave your indulgence for a few words relative to the "Mitis process." The word "mitis" is a Latin adjective, meaning mild, soft, or ductile, and it was selected because of its appropriate signification, as the designation of the new art, by its Swedish inventors.

I regard this process as one of the most important improvements in the metallurgy of iron and steel that has been brought forward during the past twenty years. By its means we can produce castings of melted wrought iron, or of steel of any desired hardness, that, without having been annealed, can be forged, welded, bent cold, or worked by machine tools, with as great facility as ordinary forgings of wrought iron and steel.

From among various samples I have selected two articles which will serve to give a good idea of the possibilities of the new art. One of these is a horse-shoe with "nail holes" and "creases" complete, cast of melted wrought iron in an iron mould—an impossibility by any other process. The other is a beefsteak pounder, in the condition in which it left the "dry composition" mould in which it was cast; this also is made of melted wrought iron. On the extremity of each tooth there is what appears to be a wire. These seeming wires were made by the melted wrought iron filling the "vent holes" of the mould; a thing which I never saw to anything like the extent shown in this sample in the case of castings made of any metal by any other process. In fact, one of the most remarkable attributes of this new art is the extreme fluidity of the metal at the time of casting, and in this fact is one of its greatest technical advantages; for this exceeding fluidity enables all the "blow holes" to escape before the casting or ingot solidifies, thus getting rid of one of the chief obstacles to sound forgings in iron and steel.

This fluidity of the melted metal is produced by the addition of a small percentage (0.05 to 0.1 of one per cent) of the metal aluminium to the melted wrought iron or steel immediately before casting: this addition at once produces a degree of fluidity in the molten metal comparable with that of water.

The reason for this result cannot be explained, but it can perhaps be made more comprehensible by an illustration.

The soft metals—tin, lead, zinc, antimony, bismuth, etc.—melt singly at temperatures varying from 600° to 1000° F., but if a proper selection and combination from these metals be made, we shall obtain an alloy that will melt at the surprisingly low temperature of 170° F.

Under ordinary conditions, melted wrought iron or low steel is pasty or semi-fluid, and it has been found that, without increasing the temperature, the addition of the small percentage of aluminium named acts upon the metal very much as the soft metals in our illustration act upon each other,—it increases the fluidity of the mass, and thus enables results to be attained that have hitherto been impossible. Castings made by this process are, as a rule, ten per cent stronger than the scrap iron melted to produce them ; and in the case of steel there is a like increase of strength without any diminution of elongation previous to rupture, a property which is of great practical value. I regard this process as of great value in the manufacture of material for great guns, as by its use sounder and stronger ingots of steel can be insured from which to forge the component parts of built-up guns; and, furthermore, I believe it quite possible, by the use of this process in connection with the Rodman system of casting, to make a solid cast-steel gun that will be more efficient and a great deal cheaper than any built-up gun can possibly be.

The question of national defense is no trivial one, and before deciding upon the method to be adopted in the manufacture of our future arms, the merits of all systems should be carefully considered. The laudable purpose of our government to provide adequately for the defense of the nation gives to the general subject of the manufacture of heavy guns great interest at this time. That people who would preserve peace must be prepared successfully to defend peace; and a nation so prepared will rarely need to use its weapons.

The industrial victories of peace make possible war's triumphs in the defense of peace. And therefore a nation's first step in its own defense should be to foster the industries of its own people, and cordially encourage those who, with thoughtful brain, willing hand, and ready purse, stand prepared to mine coal and ore, to make furnaces roar and melt with fervent heat, while mighty engines throb and ponderous hammers beat, and, anon, gigantic tools, in whose stalwart frames and cunning fingers are crystallized the brain and brawn of generations of workers in thought and substance, give final shape and proportion to the arms of our defense, that peace and concord, prosperity and happiness, shall be ours while time endures. To this end should all labor tend—

> "Till the war drum throbs no longer, and the battle flags are furled,
> In the Parliament of man, the Federation of the world ;
> When the common sense of most shall keep a fretful realm in awe,
> And the kindly earth shall slumber lapt in universal law."

DISCUSSION.

Lieutenant R. R. INGERSOLL.—*Mr. Chairman and Gentlemen* :—I have only one objection to offer to what the author has said in his able and instructive paper, and that is as to the possibility of making a modern gun with Mitis iron or steel by the aid of the Rodman process of casting. There is but little doubt that a sufficiently strong gun cannot be produced by the Rodman system of casting, for the simple reason that, however beautiful the theory, it is impossible to realize in practice the state of initial compression of the bore indicated by the theory. This is conclusively shown in the case of cast-iron guns, the process of casting which is very much easier than is the case with steel guns. The elastic limit for compression of cast iron being taken at about 26,000 pounds per square inch, the initial compression at the surface of the bore of the completed gun should equal this amount in order to compete with built-up guns ; but thus far, an initial compression of 12,000 pounds, in the case of the 12-inch cast-iron gun built at South Boston, is about the limit reached. Again, the elastic strength of Mitis iron being, as compared to gun steel, not over two-thirds the latter, the material is not sufficiently strong, especially in view of the fact that the day is not far off when 2500 f. s. and 25 tons pressure per square inch will be as common as 2000 f. s. and 15 tons pressure per square inch are to-day.

I am glad to hear the author take such strong ground as he does in regard to the existence of blow holes in steel castings. It is as strong an argument as can be desired against the practicability of producing sound, strong guns of cast steel by the Rodman process.

The paper is most interesting and instructive, and I regret that the author is not present, because he could, perhaps, clear up many points upon which some of us may possibly be doubtful.

The following reply to Lt. Ingersoll's remarks was received by letter :

MR. DURFEE.—*Mr. Chairman and Gentlemen* :—In reply to the criticism of Lieutenant Ingersoll, I will say that the behavior of melted wrought iron or steel, when treated by the "Mitis Process," is so different from that of these metals not so treated that, in the absence of actual experiment, it is hardly just to assert that this new process is not available for the manufacture of heavy guns by the Rodman system, or some modification thereof ; and if a thorough trial should prove its unfitness for use in this way, it could hardly fail to be of great value in ensuring sound ingots from which to forge the parts of built-up guns.

In view of the many failures of built-up guns made by the aid of the best talent and largest experience abroad, I think it the part of a conservative wisdom to hasten slowly enough in this (for our country) new manufacture ; to "prove all things and hold fast that which is good."

On the motion of Commander W. T. Sampson, a vote of thanks was given to the author for his valuable and instructive paper.

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

May 6, 1887.

Commander P. F. Harrington, U. S. N., in the Chair.

A NEW METHOD FOR CARRYING AND LOWERING, AND FOR DETACHING BOATS; ALSO A SUGGESTION FOR DEFENDING SHIPS AGAINST AUTO-MOBILE TORPEDOES.

By Lieutenant D. H. Mahan, U. S. N.

Mr. Chairman and Gentlemen:—The models I wish to exhibit to you this evening I have spent a great deal of time and thought upon, but until now I have hesitated about presenting them.

I.—For Carrying Boats at Sea.

My plan, which I hope will elicit the ideas of others, is so to carry boats on board ship that they may all be lowered, either on one side or the other, or on both sides, as the case may require. How to do this I will explain by experiments with my model. First, I have the arms in position to receive the boat as soon as hoisted. Let us hoist the boat to the davit-head. As soon as hoisted, men on the rail turn the cradles under the boat and the guys are set up. The boat is lowered into the cradles and hauled inboard, the falls being unhooked. Carrying the boat across the ship and hooking the other falls, we prepare to lower the boat by running the cradles to the outer ends of the arms and hauling taut the falls. (This is the position of the boat, if at sea and expecting to sight an enemy's fleet.) Two men on the rail unhook the brace bars. As soon as the bars have been lowered, a man stationed on deck, by bearing down on the triggers, immediately removes both cradles from under the boat, and the men on the rail turn the cradles alongside the ship in either direction. The boat can now be lowered.

The arms are raised into place by hooking the boat falls into the hook on the ends of the arms. Since the guys have not been let go, the arms will swing into position as soon as hoisted, and owing to the shape of the joints will catch of themselves. As soon as hoisted, the brace bars are hauled up into place. If it be desired to get a second boat out on the same side:—before hoisting the arms into place, hoist the cradles already on the arms inboard, and then hoist the arms into place and run the second boat out. In case of a ship in danger of foundering, there will be no necessity for hoisting the arms into place, but instead run the second boat out, steadying the cradles by the in and out tackles, and when the falls are taut, ease out and allow the cradle to go overboard.

My idea is to have the boat carriage and cradle made of paper, so as to reduce the weight as much as possible. If it be desired to change cradles, it can readily be done by removing the bolts which secure the cradle to the carriage. The carriages are secured at sea by wedging up, thus raising the rollers from the tracks and at the same time pressing the clamps of the carriage close against the under side of the track.

DESCRIPTION OF MODEL—PLATE I.

a, boat carriage and cradle, made in two parts and bolted together. The cradle depends on the style of boat used. The carriage is a simple oblong box, without a bottom. It has eight rollers inside of it, placed in pairs. There should be a bolt-ring at each end and in the centre of each side, used for tackles. The carriage has a clamp at each corner, passing under the track to prevent the carriage from tilting forward or aft.

b, outrigging arm forming a continuation of track. At the outer end there is an upright, *v*, which prevents the cars from running off the track.

c, track across ship, T-shaped. This track is supported by stanchions *t*; outboard of the stanchions the lower part of track is cut away to leave room for the wheel which is required to turn the cradles from the boat.

d, supporting arms for *b*, moving around a bolt at *f* and at *g*, hinged at *e*.

e, hinge.

f, bolt.

g, a movable collar working on *h*, self-adjusting when raising or lowering arm *b*.

h, upright bar, resting in casting step *i*, passing through casting *k*, and having wheel *n* secured to its upper end.

i, casting secured to ship's side.

k, casting secured to ship's side.

m, support for inner end of arm *b*, having a bolt passing through the sides of *m* and through *b*. This support is secured to *h* just clear of *k*.

n, wheel secured to head of *h*, used to revolve that bar.

o, on one side shows position of pin on which the brace bar *p* rests; on the other side, how the brace bar is cut to rest on the pin.

p, brace bar, intended to prevent the hinge *e* from giving away unless intended. These bars have to be removed before the cradle can be lowered.

q, line leading from near hinge *e* to head of lever *s*. This line breaks joints as soon after the brace bars are lowered as desired.

s, lever intended to tauten line *q* when breaking joint *e*, thus allowing arm *b* with carriage and cradle to drop from under boat. There are two levers, one to each arm, so placed on a bar running fore and aft that a movement of one causes a corresponding movement of the other.

t, stanchions supporting tracks; there are other stanchions in amidships.

v, upright at end of track to prevent carriages from running off.

w, hook by which arm is hoisted into place again.

This model was conceived some years ago, but I had laid the drawings aside. Two years ago I was reading Commander Hoff's book on "Examples, Conclusions, and Maxims of Modern Naval Tactics," in which he writes as follows:

"Will not the lowering of torpedo boats just previous to an engagement be fraught with danger, by giving the enemy a chance to concentrate and ram you?"

"To get the boats into the water, speed must be reduced."

"Now, if at this stage either fleet attempts to get the torpedo boats into the water, the other fleet would have a great advantage if they bore down upon them at full speed and engaged them."

"Two fleets meeting at night . . . . your torpedo boats cannot be gotten into the water."

"Captain Rivet is of the opinion that no faster speed than 8 or 10 knots will be maintained during an action."

These passages determined me to perfect this model, as I knew that I had the means for lowering and detaching a boat while the ship was making 11 knots. This apparatus I will describe to you, and will also read a few extracts from the report made upon it by a board of naval officers.

II.—Boat-detaching Apparatus.

The castings are made the same for all boats, but as they are only three inches wide, a dinghy would not be much encumbered by them. The theory of this detaching apparatus is, that a hook with its centre of gravity above and outside of the centre of motion is bound to fall if uncontrolled. The hook is one inch in thickness. The controlling bolt is one of my own designing, as I wanted one that would not slip out and that could not be entirely pulled out. The first condition is obtained by means of a detent operated by interior springs, which keep the detent out unless compressed by the drawing of the bolt through the hole when about to detach the boat. The second condition is obtained by expanding slightly the inner end of the bolt and making the inner edge of the bolt hole slightly concave. The working part consists of two pieces of light wire rope passing under the beading on the outside of the boat, and connected one to each bolt; the other ends are made fast to two handles on the inside of the boat in the stern-sheets. Pulling the after handle disconnects the after fall,—the forward handle controls the forward fall. The boat must be water-borne to disconnect in this way. I believe this to be the only apparatus which will disconnect one end at a time.

Permit me to introduce here a few extracts from the report.

"In order to give the apparatus a trial under circumstances as near as possible to those in actual service on board a sea-going vessel, the boat was hoisted to the davits of the U. S. tug Monterey, and taken to the entrance of San Francisco Bay, where a topping sea was met, in which she pitched and rolled heavily.

"While going at full speed, making about 11 knots, sea a little on the bow (same side as boat), the boat was lowered with bolts withdrawn, and immediately upon striking the water freed herself from the tackles. Before a second trial could be made in a sea-way, the boat swung inboard, owing to the absence of guys, and span upon the davits, was partially stove, and swamped by the unhooking of the forward fall, thereby preventing further rough-water trials.

"In smooth water the boat was lowered a number of times, both while at rest and going at full speed, in all of which cases she cleared herself successfully. In all these cases the bolts or keys were withdrawn before lowering.

"The trial was then continued with the bolts or keys in place, properly attended and withdrawn at the word of command, after the boat was water-borne, with the same success as before.

"It is evident that the invention has several advantages, such as simplicity, cheapness, strength, non-liability of getting out of order or of being in any way obstructed by passengers, freight or boat equipment, facility with which the boat clears herself from the tackle when water-borne, and great ease in hooking on for hoisting in a sea-way.

"The principal disadvantages appear to be the necessity of lowering the boat square, or a little by the stern, and a careful attendance of the bolts so that they may be instantly withdrawn upon the boat striking the water, a difficult matter in moments of haste or excitement."

Now, the first of these disadvantages is common to all boats, as no one would lower a boat bow first with a ship moving ahead; the second appears no longer to be a disadvantage when the necessity of knowing the boat to be safe in the water before letting her go from the falls is considered.

Seamen differ as to when the boat should be let go, and some have said to me that my apparatus would be excellent were one able to detach the boat in mid-air. To afford no ground for such a complaint, I have had fitted to this boat an arrangement by which the boat can be detached in mid-air, and in putting it into the boat it is so arranged that the stern will start an instant before the bow, thus doing away with the necessity for lowering the boat square or a little by the stern. This mid-air arrangement can be taken out when in port, as there is then no necessity for its use. The hole for the mast is used, and the step for this little windlass can be used as a step for the mast.

With this addition to my detaching apparatus, I claim that a boat can be detached in any way and at any time that may be desired, and, moreover, with perfect security against accidental detachment. I can detach either end first, or both at the same time; either in the water or in the air; with the ship lying dead in the water or going at full speed; and with the boat loaded or empty. Everything connected with the apparatus is above the line of thwarts and all parts are easy of access. Then, again, you can get into the boat and play with the apparatus and it will not go off. If, while a boat was being lowered with bolts withdrawn, a sea should strike near the bows, both ends would unhook. If this should not happen—if the bow only unhooked—upon letting go the after fall, the boat would free herself.

The following experiments have been tried successfully:

1. Disconnecting both ends when water-borne, no one in boat.

2. Disconnecting bow when water-borne, no one in boat.

3. Disconnecting stern when water-borne, no one in the boat.

4. Disconnecting both ends when in the water, a man attending the bolts.

5. Disconnecting bow when in the water, a man attending the bolts.

6. Disconnecting stern when in the water, a man attending the bolts.

7. Disconnecting in mid-air, both ends.

8. Disconnecting in mid-air to show that the stern starts first.

9. Stepping on bolt lines to show that bolts will only draw by a direct pull.

10. Swinging boat with bolts drawn to show that the apparatus will not detach by any motion of boat.

DESCRIPTION OF MODEL—PLATE II.

Fig. I. Shape of boxes as used in bow and stern.

Fig. II. Shape of boxes when placed more towards the centre of boat.

a, ring attached to lower block of boat fall.

b, hook,—its shape shows why it falls if uncontrolled.

c, hole for controlling bolt.

d, hole for bolt around which hook revolves.

e, hole for use in towing, being towed, or by means of which the boat could be suspended if desiring to overhaul detaching apparatus.

f, holes for riveted bolts.

Fig. III. Shows three views of controlling bolt.

1, bolt showing detent open, and flare of bolt.

2, bolt showing hollow for detent, slot in detent, shape of detent, and springs out.

3, same as 2, but with springs compressed.

m, head of bolt, showing hole where the line is fastened.

The mid-air detachment consists of a very small windlass placed on the after thwart, fitting through the mast hole and into its step. Two lines are led from the windlass, one to the forward hook, the other to the after hook, and fastened to the holes in the heads of the hooks marked x. The after line is of such a length as to tauten an instant before the forward line. As long as the bolts are in the boat cannot be detached,—but withdraw the bolts, ship the lever and heave on the windlass, and a motion through an arc of 20° will detach the stern; through 30°, the bow.

III.—Proposed Defense against Auto-mobile Torpedoes.

In proposing this protection I would like to say that other protection would be necessary against large torpedo boats, this one merely protecting the ship from auto-mobile torpedoes. The combination of two spars, one for the head and the other for the foot of the netting, will keep the netting in place even while going ahead. The nettings are continuous, from well ahead to well astern on each side, and are made in sections of from twenty-five to thirty-five feet. The spars are fitted with guys forward and aft; with distance chains, so that they cannot fall farther than intended; and with chain running from one spar to the other, which facilitates rigging in and out. To the ends of the upper spars are secured the boat falls, or a runner with fall inboard, if in way of gun, the hauling part leading to steam winches on upper deck. To the outer end of each of the lower spars leads a single line, passing through a block at davit's head, and used for easing out the lower spar until the chain between the two spars is taut, and also, if desired, for hauling the lower spar close alongside when hoisted sufficiently by the falls.

Suppose now that the nettings were down and it was desired to get under way. Start all the steam winches, and in five minutes the nets would be clear of the water, the upper spar would be perpendicular, and the lower spar so much raised that the net would be nearly horizontal and above the guns. If not clear enough, rig in the lower spars, allowing the netting to bag between the two spars and lie close alongside the ship. Lowering the netting on either side, in case a torpedo should be observed approaching, can be easily accomplished, and will retard the speed but little. The spar castings a are the only stationary parts; the spars themselves can either be unshipped or the longer ones be used for awning stanchions.

Description of Model—Plate III.

AB, water line.
a, castings for netting spars.

b, castings for heel of davits.

c, sleeves for davits.

d, spars for head of netting.

e, spars for foot of netting.

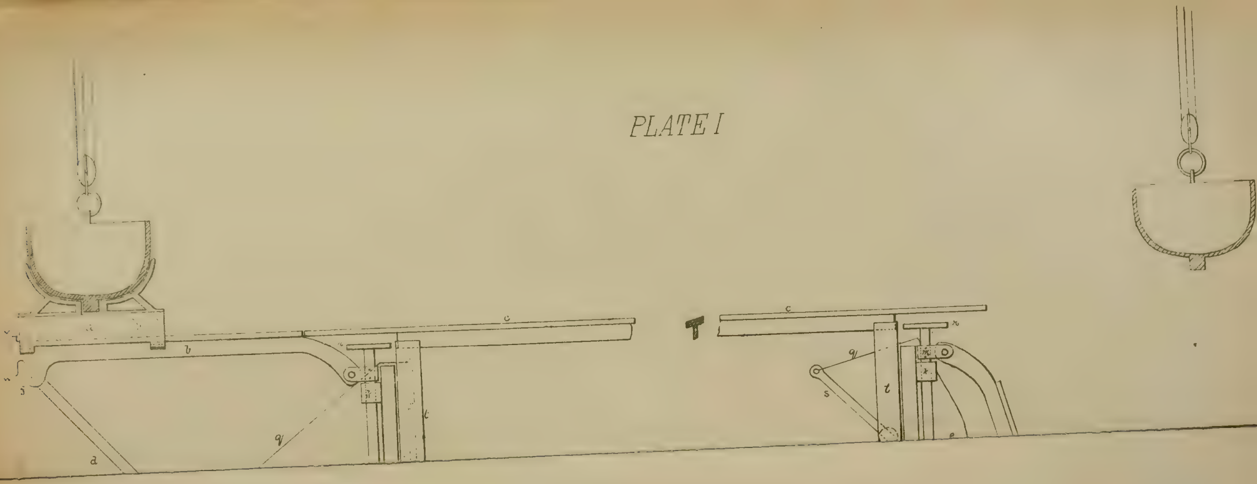
These spars *d* and *e* should be fitted with universal joints. The guys secure half way out. The setting up of the netting from forward guys the outer end of the spars.

m, falls leading to winches.

n, whip to trice in lower spar.

o, heavy thimbles for lashing or hooking sections of netting together.

PLATE I



b, castings for heel of davits.

c, sleeves for davits.

d, spars for head of netting.

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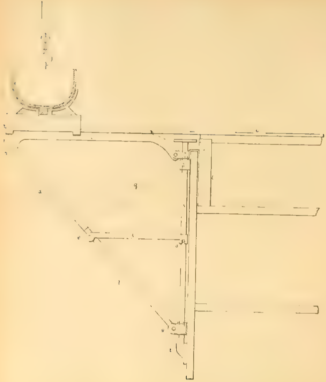
PLATE I



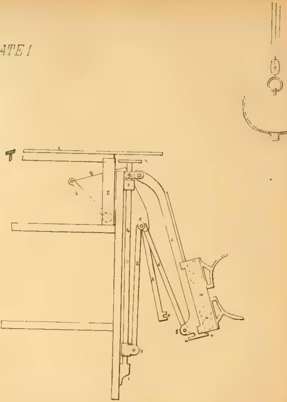
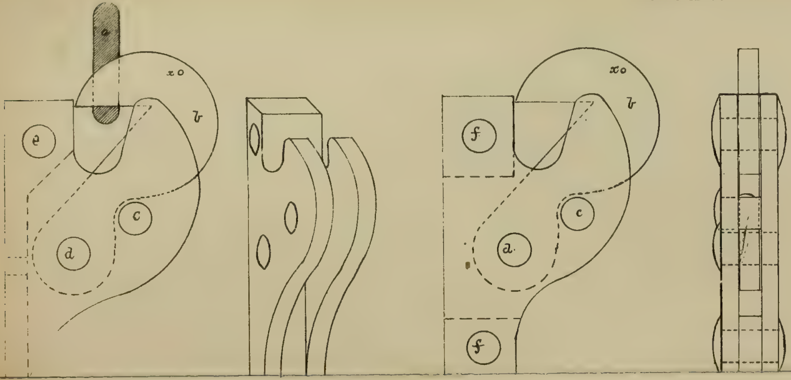


PLATE II



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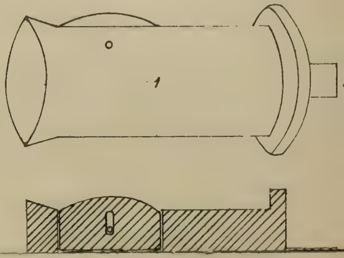
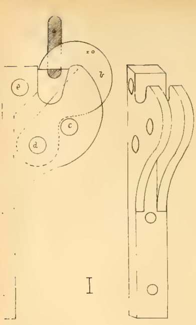


PLATE II



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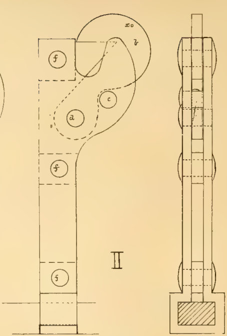


II

III

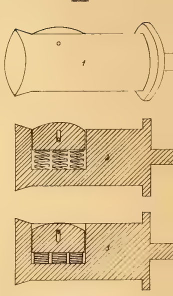


PLATE III

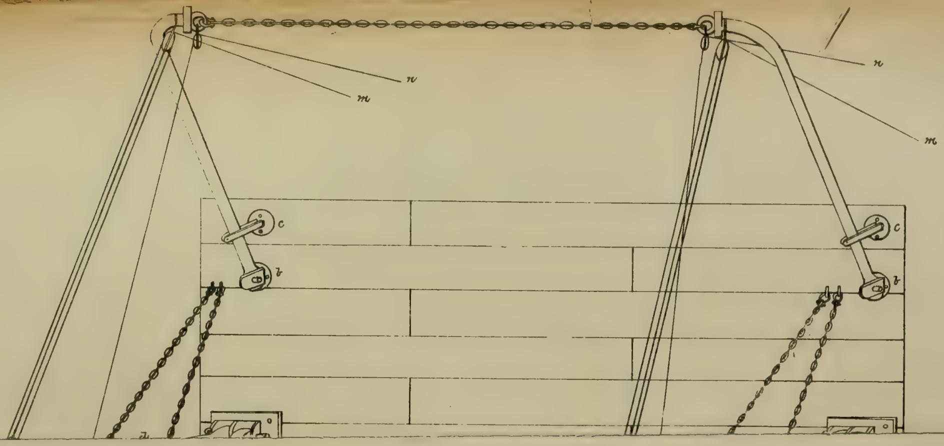
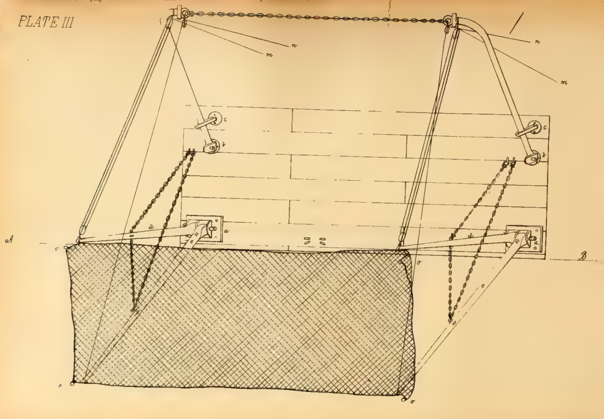


PLATE III



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U. S. NAVAL INSTITUTE, NEWPORT BRANCH.
JUNE, 1887.

NOTES ON THE LITERATURE OF EXPLOSIVES.*

BY CHARLES E. MUNROE.

No. XIV.

Under the title of "A Remarkable Explosion," Prof. L. R. F. Griffin describes, in the *Popular Science Monthly*, **30**, 810–814; April, 1887, the circumstances attending the explosion by a stroke of lightning of one of Laflin and Rand's magazines at Brighton, Ill., August 29, 1886. The magazine was one of a group of eleven, standing on a comparatively open area of some forty acres, and it contained at the time of the explosion fifty tons of black powder and fifteen tons of dynamite.

The shock of the explosion was felt in Chicago, seven miles distant, as a sudden jar followed by a dull thud like that produced by a distant gun of large size. It was sufficiently violent to shake buildings six miles distant, so that, although a very severe thunderstorm was occurring at the time, guests in some of the hotels rushed frantically down-stairs, suspecting an earthquake. Plaster fell in the Immanuel Church, more than five miles away, so that it was at first supposed to have been struck by lightning, and a large plate-glass window in the Board of Trade building, about seven miles distant, was cracked, and the clock on its tower was put back three seconds. Examination of the locality of the explosion showed that the brick walls of the magazine had been pulverized and scattered over a wide area; the limestone foundation was torn up and a large part of the material broken into small pieces, the most of it carried through the air from forty to eighty rods; and a hole was torn in the ground, there mainly tough clay, about one hundred and fifty feet long, forty feet wide, and from ten to twenty feet deep. All the buildings in the immediate vicinity were demolished, while those which stood within reach of the flying stones were more or less riddled. The loss of life was very small considering the extent of the damage, only one person having been killed outright, although several others were severely injured, of whom some have since died.

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*As it is proposed to continue these Notes from time to time, authors, publishers, and manufacturers will do the writer a favor by sending him copies of their papers, publications or trade circulars. Address Torpedo Station, Newport, R. I.

Such are the primary facts of the explosion itself. An examination of the ground in the vicinity, and of many of the buildings ruined near by, together with others at considerable distance more or less injured, developed certain minor facts that bear upon the general subject of explosions. Especially do they seem to show that such explosions may produce an earth-wave which may do damage at great distances, the undulation of the ground displacing objects, cracking walls, and shattering glass, much like an earthquake in miniature. Sometimes this may possibly prove the source of the principal destruction.

Looking directly at the destruction itself, the results of the explosion appeared as follows: The buildings nearest the wrecked magazine were all crushed together, and, so far as could be determined from the ruins themselves, were pushed away bodily from the demolished building for a short distance, not more than one or two feet. This shows that the explosives instantly produced a very large volume of gas, which forced itself against the surrounding air and condensed it very quickly, until it gave way in the direction of the least resistance, which would necessarily be upward. This condition was confined to a small circle; for, while such a condensation would produce a wave of air, the mass bodily displaced must be confined within comparatively narrow limits. Displacement would not appear beyond.

Fortunately, at Brighton, no other magazine stood within this area, so that the dynamite in the others was unaffected by the shock, while the rain prevented the fire from spreading by means of dry powder. Outside of this area there was a narrow ring or circular strip of ground, with a radius of not far from fifteen rods, where comparatively little injury was done. One or two magazines stood in this region, and they escaped almost without injury, only being slightly battered by flying stones. Here the air was not moved as a mass either way. The changes of density to which it was subjected were of the nature of molecular movements rather than motion of any great mass of air. Beyond that area the movement of the air was toward the point of explosion. This was shown by the forcing of the glass outward in all of the more distant buildings, while the walls of at least one dwelling-house and of several of the magazines left standing were thrown down toward the wrecked magazine. Furthermore, the roof of one magazine was clearly lifted and allowed to drop, besides being riddled with stones. These phenomena pointed clearly to diminished pressure of the external air, produced by the explosion, as is noticed in a small way when any gun is fired. Since most of the magazines stood in this region, no blow was struck upon them, and there was nothing to explode the dynamite stored within, else the first explosion would have been followed by others in a series and the damage multiplied.

These phenomena, taken together, seem to indicate the following as the steps by which the destruction was produced, though they followed so quickly that only delicate instruments would have distinguished them: First, the lightning exploded some of the black powder. The blow produced by this explosion detonated (?) the dynamite, tearing up the ground to make the hole, and breaking the foundation stone into small pieces. Then the rest of the powder exploded, sending the fragments away in all directions.

It is very strange that, when the danger from lightning is so well known—one of the same group of magazines was exploded by lightning in 1880—no precautions are taken by the owners for protection. The magazines are low structures, some of them roofed with slate, others with thin metal, in all cases very light, that they may offer but little resistance in case of explosion. The total neglect of precautions against lightning indicates a disregard of the known laws of electricity, or else the mistaken notion that a lightning rod, by furnishing a good conductor, attracts the lightning, and thereby increases the danger in place of being a safe path for the current. When such buildings stand upon level ground, in open areas, they necessarily become the path of any descending flash. If the electricity goes through the building, it becomes a source of danger, because it is likely to meet sufficient resistance to raise the temperature above the igniting point of powder, and it must be carried completely around the powder to insure safety. A network of metal rods carried over the tops of those whose roofs are slated, and given a sufficient ground connection, would be a complete protection; it would carry away all the electricity, usually silently. To protect those with metal roofs, nothing more would be required than wide strips of metal from the roof itself to the ground. Of course, in either case, great care must be taken to prevent scattering powder on the ground within reach of electricity as it leaves the conductors. The problem of protection in this case has sometimes been compared with that of the protection of tanks in which petroleum is stored. This is a complete misconception. Protection of powder magazines simply requires a proper conductor to carry off the electricity, silently if possible, but so completely as to allow no escape in case of a flash. There are no complicating conditions, such as petroleum tanks present. Nothing, either in the material itself or in the air around, makes that a better conductor than neighboring objects. But in the case of petroleum tanks, gases are constantly rising from the petroleum and escaping into the air around, and particularly directly above. They frequently rise many feet above the tank, and experience proves that the gas, or the mixture of air and gas, is a much better conductor than the air itself. So the tank is likely to become the path chosen by every descending flash, and the problem of protection is not simply to furnish a conductor from the top of the tank, but one that shall conduct the electricity from the top of the ascending gas, always an uncertain height. So far no plan has proved completely successful.

The phenomena show clearly that two sources of danger arising from such terrific explosions must be guarded against. The glass broken within the first two miles proved a rush of air toward the destroyed magazine. The sudden uprush of gas, the mass being very highly heated, caused a vacuum, and the subsequent cooling added to the effect. The air rushed toward the vacuum from all directions, and when it was contained in a confined space, as a closed room, it quickly broke the glass, shattering it into small fragments, which fell outward. But the force which did this work was spent within a comparatively narrow area. Beyond that it only appeared as the back-and-forward movement of an ordinary sound-wave. The distance to which this was carried could not be determined, because beyond some seven or eight miles the report was not distinguished from the ordinary roll of the thunder.

This explosion produced an earth-wave as well as an air-wave. The force of the dynamite, exerted largely downward (?), not only tore the ground out to make a hole, but forced it away sidewise in all directions. This formed a ridge around the hole, and at the same time it produced a wave, that is, an up-and-down movement of the earth. One observer, who was sitting quietly in a chair about six miles from the magazine at the time of the explosion, described the sensation which he felt as a quick movement down and up again. He was not quite positive which preceded, the motion upward or downward, but he thought that downward. That would indicate that the upward motion of the earth was first, since the human body has the sensation of moving in the opposite direction to the motion of the wave, and that agrees with the appearance of the hole. This earth-wave made dishes rattle in all places where it was felt perceptibly. In the central part of Chicago many plate-glass windows were cracked. These were injured by the earth-wave, not by the air-wave. They were simply shattered from the motion of the surrounding walls, but were not forced either inward or outward. One observer stated that a pane of glass near him was cracked at the moment when he felt the shock, not when he heard the report, which was a little later. This showed that the earth-wave moved faster than the air-wave which produced the sound. There is also reason to believe that this earth-wave travelled much farther than the air-wave. A self-recording barometer in the laboratory of Lake Forest University, about thirty miles distant from Brighton village, showed a sudden movement of the mercury at about that time, which could be accounted for only by referring it to the wave of the explosion. Probably this was not the limit of the movement. Unfortunately, there was no means of determining the rate at which this earth-wave moved. All these conditions combine to surround this remarkable explosion with peculiar interest.

The *Boston Herald* of June 6, 1887, gives an account of a new projectile, known as the Fannon-Winslow shell, which has been perfected by Massachusetts inventors. The idea of the inventor is to place three bottles containing the components of nitroglycerine in the interior of the shell, so arranged that they will crush and their contents mix when the shell strikes any object. Very powerful results are said to have been produced with this projectile.

A report of the trial of the Winslow shell by a board of ordnance officers will be found in the *Report of the Chief of Ordnance U. S. A., Appendix* 15, pp. 103–104, 1885. They describe the projectile as being formed, like a Butler shell, with an appendage resembling a cascabel. The neck of the appendage, to which a wrench is fitted, is hexagonal. The part corresponding to the knob is a cylinder terminating in a spherical segment. The projectile is divided into two sections. The anterior part is a cylinder with an ogival head, and contains a cavity in which the ingredients to produce an explosive compound are contained. This section terminates at the rear end in a screwed tenon, by means of which it is fastened to the rear section. The rear section is provided with a cavity intended to receive a cast-iron plunger and a charge of rifle powder. Near the base of the projectile is a circumferential groove in which time-fuse composition is driven. This groove is connected with the rifle powder in rear of the plunger. An axial chamber is bored in the plunger and contains a small charge of rifle powder. The rear of this chamber is closed by a screw-plug, containing a vent filled with slow-burning composition.

The materials used for producing an explosive compound are glycerine and concentrated nitric and sulphuric acids. One pint of sulphuric acid and three quarts of glycerine were mixed in one vessel, and three pints of sulphuric acid and two quarts of nitric acid were mixed in another. A portion of the first mixture was placed in a glass jar, while a small jar placed within the first was filled with a portion of the second mixture. The liquid contents of the inner jar and of the outer jar when the inner one is inserted are equal in quantity, hence the proportions of the liquids are: sulphuric acid 2, nitric acid 2, and glycerine 1. The usual proportions, when nitroglycerine is manufactured by the ordinary processes, are about as follows: sulphuric acid 6, nitric acid 3, glycerine 1.

The jars are fastened together by screw-caps, and are placed within a tin cylinder, open at both ends, which fits the shell cavity. Stout cross-bars traverse the open end of the cylinder, and the exterior glass vessel is fastened to the bars by strong bands, which, aided by rubber straps, are designed to prevent the rupture of the jar when the piece is fired. The rupture is intended to be effected in the following manner: The time-fuse is cut at any point, and when the projectile has traversed a certain portion of its trajectory, the charge of rifle powder in the rear of the plunger is fired and the plunger is forced violently forward. This breaks the bottles, and, in connection with the rotation of the shell and the broken fragments, causes an intimate mixture of the glycerine and the acids, resulting in the formation of an explosive compound. When the projectile strikes a resisting object, the shock of impact should (according to the report) cause the explosion of the compound thus formed, or, if this does not occur, then the charge contained in the axial chamber of the plunger will bring about the explosion.

The trial commenced April 23, 1885, when a shell was fired over water from an 8-inch muzzle-loading rifle with 35 pounds of powder. It could not be ascertained whether or not an explosion had taken place, for from the fragments that struck near the gun it appeared probable that the projectile had been broken up by the shock of the discharge. A second round was fired over land with 30 pounds of powder, the fuse being set at five seconds. The shell burst in the air in two and one-half seconds, and from the peculiar appearance of the smoke the rupture was regarded as due to the explosion of a substitution (?) compound. In the third round, fired with a 30-pound charge, over water, no explosion took place. The fourth projectile was exploded by means of an electric primer in an inclosure. The shell broke at the screw-thread into two pieces, the head being thrown some 25 feet out of the inclosure. The bottom was forced against the side of the inclosure.

In conclusion the board report that the acids can be safely transported to any point, the mixture can be effected without danger, and a shell arranged to contain them may be fired from a gun without injury to it. With the mixture used an explosive compound is probably formed, although the proportions of the ingredients used were not such as to give the best results. If they had been, and if the greatest possible amount of nitroglycerine producible by the ingredients which the shell cavity could contain were formed, it is not thought that the effect would be equal to that resulting with an ordinary bursting charge of gunpowder. The board therefore recommend that no further trials be carried on with this device or with devices closely resembling it in principle.

This same volume of the Reports of the Chief of Ordnance contains, on pages 57–59, a report of the tests of the 6-inch shells on the Snyder system* charged with dynamite. The board conclude that it is impracticable to fire shells containing commercial dynamite from a smooth-bore gun when a suitable powder charge is used under this system, and although previous experiments by the board have indicated that explosive gelatin can be successfully fired from an 8-inch rifle with a charge of 40 pounds of powder,* and therefore could be safely employed in this case instead of commercial dynamite, yet they do not consider that any trial with it in this system would be of any value, because the projectile employed possesses little penetrative power, and, furthermore, the system is very complicated and expensive. The board does not recommend further experiments with it, since simpler and less costly methods promise greater and more valuable results.

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* Proc. Nav. Inst. **12**, 617; 1886.

On pages 79–80 of the above report is a description of "M. L. S. Buckner's Aerial Drop for Explosives," which is a method of using high explosives from balloons. The board state that the machine is ingenious, and there seems to be no doubt that it will work and drop its explosives at the fixed time to which the alarm-clock may be set. The machine has to be suspended from a balloon, and to be efficient would require a very accurate knowledge of the force and direction of the wind at different elevations, and, of course, at best could only be used under the most favorable circumstances, and when the wind was blowing in the direction of the object to be reached.

The *Army and Navy Register*, June 11, 1887, p. 380, states that Lieutenant J. W. Graydon (late U. S. N.) has devoted his attention to explosives, and has undertaken—

1. To charge ordinary shells with dynamite in such a way as to render it safe to fire such projectiles from heavy guns with service charges of powder.

2. To use dynamite and powder together in the charge, thereby obtaining an increased velocity without a corresponding increase of pressure in the chamber of the gun.

3. To produce a new explosive which shall be safer while at the same time very much more powerful than ordinary dynamite.

Last winter experiments were made at St. Petersburg with the shell filled with dynamite, and the projecting charges consisting of dynamite mixed with black powder. Four charges of the mixture of thirty-seven pounds each were fired from a 6-inch gun, Navy pattern, the shells containing 102 pounds of dynamite. The velocity was

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* Report of 1884, Appendix 17.

1993 and the pressure 1736. Four service charges of thirty-eight pounds of powder, with 102 pounds of powder in the shell, gave a velocity of 1499 and pressure of 1724.

Graydon's method of charging shells was tested by a board of army officers at Presidio, Cal., in 1886. They reported, August 13: "We have witnessed the results of fifty-two shells filled with commercial dynamite fired with the service charge of powder from the 4½-inch siege gun, and they were all fired with perfect safety to the gun, with the exception of two, the results of which were lost on account of the fog. Every shell that struck the bank or cliff fired at (range 2200 yards) exploded by concussion, no fuse being required for the explosion. It is the opinion of the board that Mr. J. W. Graydon has solved the problem of firing shells with dynamite with perfect safety to the gun, and at the same time making explosion sure upon the impact of the projectile; and, pending a full and extended report upon the experiments, the board unanimously recommend that experiments be continued with the 8-inch rifle converted and the 15-inch smooth-bore."

Experiments on this method are to be made at Sandy Hook with the 100-pounder Parrott and 7-inch wrought-iron guns.

The *Revue d'Artillerie*, **30**, 530–538; 1887, reprints from the *Militaire Spectator*[*] *of Breda* an article on "The Use, in Germany, of Gun-Cotton for Charging Projectiles."

In 1883 Messrs. Von Förster and Wolff took out two patents—one for a process for preserving gun-cotton,[†] the other for the construction of a shell charged with this explosive. The process of preservation invented by Von Förster consists in plunging the gun-cotton, wet or dry, into ether for 15 to 20 seconds; there is formed on the surface a very thin, hard layer impermeable to water and of a yellowish-brown color, thus giving the gun-cotton the appearance of wood. Nitro-benzene or other liquid solvents of gun-cotton may be employed in place of the ether. This layer does not affect the explosive properties of the substance, but diminishes loss by flaking and cleavage, retards decomposition, maintains the humidity at nearly the desired point, and prevents the penetration of paraffine. However, this pellicle contains always some very small interstices through which moisture may escape eventually, but this imperfection may be neglected if the gun-cotton is properly stored. Gun-cotton, not coated and containing 25 per cent of water, loses all its water in a few days if it be exposed in a brisk current of air, while the coated gun-cotton, exposed under the same circumstances, is not reduced to the dry state in as many weeks. Besides, the layer is so thin that its combustibility does not constitute a source of danger. In the case of dry gun-cotton for use as primers, after the treatment with ether, the detonator canal is plugged with paper and the disk is dipped in melted paraffine. This forms a second impermeable varnish.

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[*] Nos. 11 and 12, 1886, and Nos. 1 and 2, 1887.

[†] For a fuller account see Proc. Nav. Inst. **12**, 563–602; 1886.

The projectile described by the second patent is of cast iron formed of two parts which screw together, the interior being filled with disks of compressed gun-cotton. At the base of the shell is a fuse which fits into the perforations in the disks. The shell is provided with an ordinary percussion fuse, and this is connected with the primer by a fuse composition, which may be either gun-cotton in fine grains or a mixture of this body with meal powder, or some other nitro compound in fine grains, either alone or mixed with meal powder. The patent does not state how the fuse is held in place.

The arrangements described have been chosen as the result of experiments made at Walsrode on the effect of the explosion of gun-cotton in free air. These experiments of M. von Förster's led to the following conclusions: the power of gun-cotton increases with the density; in the moist state it is more *brisant* than when dry; it is advantageous to produce the inflammation of the charge at the part furthest removed from the object to be destroyed; and, finally, a cavity so placed as to follow the axis of the charge favors its action.

It does not appear that the shell described above has been experimented with, and later experiments on the explosion of gun-cotton in free air do not appear to confirm the conclusions reached relative to the position of the fuse and the existence of the central canal. They have, however, sought to utilize existing projectiles by devising means for charging them through the eye of the shell. These efforts have led to the taking out of another patent in May, 1885, for a method of charging and for a special mode of fixing the detonator.

The gun-cotton is used in the form of prismatic grains obtained by breaking up the compressed disks. They place 200 grams of dry gun-cotton upon the charge of wet gun-cotton. When the charge is in place they introduce a mandril through the eye of the shell, thus forming a canal in the cotton for the detonator and fuse, and they pour into this space melted paraffine having a temperature of 75° to 80° C. This paraffine fills all the interstices between the grains, and in solidifying binds them into one compact mass. The fuse is similar to the German percussion fuse, model of 1873. The plug is elongated and opened at its lower end; it encloses a capsule containing one gram of fulminating mercury, and is surrounded by a band and tube, both of caoutchouc. The whole arrangement is held in place by a screw. If they wish to obtain a retarded effect they use a longer plug and interpose a fuse composition between the exploder and the detonator. In order to assure intimate contact between the fulminate and the charge they place a 10-grm. disk of dry gun-cotton around the detonator, and protect it from the action of shocks by caoutchouc bands.

The shells are charged before being stored in the magazine, but the detonators and fuses are put in place at the time of firing. A brass tube, destined to receive the detonator, protects the charge up to this time.

In the spring of 1885 the German Government furnished the Walsrode factory with a 15-cm. gun for the trial of this mode of charging. They used lead-covered shells of 2.5 cal. model of 1869, weighing 27 kg. and having a capacity of about 2 dm^3. Each shell received a charge of 1.35 kilo. of gun-cotton, with 20 per cent of water in parallelopipedons 10 mm. on the side and 20 mm. long, and 200 grams of dry gun-cotton in cubical grains of 6 mm. on the side. They fired the charge of 1.5 kg. against a parapet situated at a distance of 70 m. The velocity, measured at 30 m. from the muzzle, was 245 m. Out of five projectiles no premature explosion was obtained. Two of them had been fitted with retarded fuses, and these produced deeper craters than the other three. The number of fragments was considerable, and their dimensions did not surpass some millimeters. A shower of fragments were thrown more than 70 m. to the rear.

They exploded a shell buried 1 m. in the earth and obtained a circular crater about 2 m. in diameter, 70 cm. deep, and of a capacity of 1.25 m^3.

M. von Förster replaced this method adopted for holding the detonator by another, which is not described, but which seems to have given good results. He pursued these experiments and proved successively all the elements of the proposed system. For this purpose they fired an empty shell furnished with an unprimed fuse, and with damp gun-cotton in the detonator, and they found that the fulminate in the capsule was not exploded. Then loaded shells containing neither fuse nor capsule were fired. There was no explosion and the gun-cotton was recovered unchanged. Next loaded shells, fused but not primed, were fired with a velocity of 420 m. against a parapet of wood, and afterwards of iron. There was no explosion, but as the resistance was increased the shells were broken up as if empty, and sometimes, though not always, the gun-cotton was set on fire.

Finally, he experimented with shell completely charged, fused and primed. More than 200 projectiles of 8.8 cm. were fired with a velocity of 450 m. The ordinary shells charged with gun-cotton were thrown from the rifled 15-cm. mortar with a velocity of 200 m., and from the 15-cm. gun with a velocity of 400 m. These last two pieces also projected steel shells of 6 calibers charged on the same system. There was no case of breaking up in the gun, and the final explosion was always complete.

In the experiments in breaking up at rest they have counted for a cast-iron 8.8-cm. shell weighing seven kilo., 200 fragments weighing over ten grams each, and 600 weighing from one to ten grams. An 8.8-cm. steel shell weighing 6.64 kilo. gave twenty-three large pieces weighing altogether 2.26 kilo., and 127 small fragments weighing together 2.865 kilo. A cast-iron shell of 15 cm. and 27 kilo. produced 376 pieces of more than ten grams, and 828 pieces of from one to ten grams. It was noticed that fragments weighing less than one gram traversed boards 25 mm. thick.

A projectile of 15 cm. and six cal., containing 9.935 kilo. of gun-cotton, buried vertically in the earth, the bottom being 25 cm. below the soil, produced a crater four meters in diameter and 1.3 meters deep, and having a crater of 7 m^3. capacity. An eight kilo. petard gave a crater of 3.5 m. diameter, 1.5 m. deep and 6 m^3. capacity; with a charge of sixteen kilo. they obtained a diameter of 5.1 m., depth 1.56 m., capacity 12 m^3.

In November, 1885, the *Revista di Artigleria e Genio* announced that the German Government had adopted the Walsrode granulated gun-cotton for charging shells.

In 1882 the German artillery began on their side experiments on the use of gun-cotton for shells. These experiments were made primarily in order to determine the possibility of using large charges in projectiles for the 21-cm. mortar. For this they used cast-steel projectiles with thin walls, and they were five calibers in length.

According to an article in the *Militaire Spectator*, the torpedo shells for the 21-cm. mortar are made in two parts, a body and a head, screwed together. The charge is enclosed in a thin zinc or iron box, and is composed of disks of compressed gun-cotton 5 cm. thick and containing twenty per cent of water. The upper disk carries a cylindrical cavity which holds a primer of dry gun-cotton, and the latter is pierced with a detonator hole. When the charge is placed in the box a rod of wood is inserted in the detonator hole, and melted paraffine is poured in to fill the interstices between the disks. The box is closed with a metal cover pierced with a hole for the detonator. When the box is introduced into the shell the head of the latter is screwed on, and a hollow screw is inserted in the eye of the shell in order to hold the box in place, and at the last moment the fuse and detonator are inserted in the aperture in the screw. The use of disks admits of greater density of loading, the charge being about four times as great as when granulated gun-cotton is used; but, on the other hand, it requires that the projectile should be in two parts, and that special disks should be made for each caliber.

These projectiles have given good satisfaction, not only in the 21-cm. mortar, but also in the 15 cm. and the 28 cm. In the latter piece the shell is loaded with fifty kilo. (220 pounds) of gun-cotton.

The article is accompanied by valuable drawings, which cannot be reproduced here.

From the *Report of H. M. Inspectors of Explosives*, 1886, we draw the following account of two accidents which occurred in the manufacture of gun-cotton. In one of these cases an engine-fitter was heating a piece of cast iron which had originally formed the plunger of a hydraulic press, when an explosion occurred. The iron piston had a hole three-eighth inch diameter down the centre to within one-half inch of the face, when the hole narrowed to one-eighth inch, and it appears that a small quantity of unsuspected gun-cotton was present in the upper part of the hole.

The other accident was of a more interesting character. A workman was in the act of removing some gun-cotton from an acid centrifugal machine at Stowmarket, when it fired and burned his face. The accident was believed to have been due either to a drop of perspiration which may have fallen on to the gun-cotton, or more probably to the presence of a small quantity of oil, the oil can having been temporarily deposited on the cover of the machine, where some of the gun-cotton may have come in contact with it. It was found on inquiry that two similar accidents had occurred previously at this factory, but had not been reported (as they should have been); and this led to inquiries being instituted as to the experience of the Government Gun-cotton Factory at Waltham. It appears that such accidents, viz. the "fuming off" of acid gun-cotton in or on removal from the centrifugals, were by no means uncommon, and these have been variously attributed to a drop of perspiration, to condensation of moisture either on the iron of the centrifugal or edge of the pot, or to the gun-cotton being wrung too dry, so to speak, and thereby becoming heated. The correspondence above referred to led to the institution, by the superintendent of the Royal Gunpowder Factory, of a number of experiments.

These experiments show very conclusively (*a*) that the presence of moisture or oil, even in minute quantities, is liable under certain conditions to produce ignition; (*b*) that such liability is sensibly diminished where mineral oils are used; and (*c*) that the liability varies to a very considerable extent with the temperature of the building.

It may be worth while to quote the following passage from a letter from Colonel Noble, Superintendent of Waltham Abbey, dated September 21, 1886, as bearing upon the subject:

"These accidents appear to occur much more frequently in hot than in cold weather. If the temperature of the air gets near 85° in the shade, the gun-cotton, after the acid has been wrung out in the machine, is very susceptible to ignition, and if a small drop of oil or a few drops of water get into it at this period it is almost certain to fume off. Instances have been known where the accident has been traced to drops of perspiration from the face of the man employed in emptying the centrifugal. You will see by experiments on the 8th and 13th September, that when the temperature was from 60° to 70° F., drops of water failed to ignite, but drops of oil or oil mixed with water never failed. One drop of oil was sufficient. On the 13th, while I was in the house, one of the centrifugals accidentally fumed off, igniting the gun-cotton in the machine next to it. The comparative frequency of these accidents at Waltham Abbey is mainly due to the very defective accommodation, which obliges the centrifugals to be worked in the same house in which the gun-cotton is purified by the boiling process."

"The Utilization of Waste Acids from the Manufacture of Gun-Cotton" is the title of an article by M. E. Allary, in the *Paint, Oil, and Drug Reporter*, **31**, No. 13, p. 9; March 30, 1887.

In the course of an examination of the waste acids from the manufacture of gun-cotton he made a number of experiments with this liquid, with the object of again using the acid for the manufacture.

1. *Simple Distillation.*—The acid used had a density of 58° B., and was filtered through quartz to remove the suspended flakes of gun-cotton which it contained. 100 kilo. gave:

10.077	kilo.	nitric acid of 50° B.
6.279	"	" " " 10° B.
82.302	"	colorless transparent sulphuric acid of 62 per cent.
1.342	"	loss.
100.000		

If the distillation is continued the 82.302 kilo. sulphuric acid of 62° B. will give 67.5 kilo. sulphuric acid of 66° B. The acids which were recovered in this way were of sufficient strength to be used again in the manufacture of gun-cotton; the nitric acid alone required a slight bleaching. By carefully conducting the distillation an acid of 48° B. can be directly obtained.

2. *Distillation over Saltpeter.*—Starting out on the assumption that, in the ordinary method of preparing nitric acid, the sulphuric acid might be replaced by the waste acids, and that on account of the increase of nitrogen oxides (the average quantity of which had been determined) a stronger acid could be directly obtained, he distilled these waste acids over Chili saltpeter, and obtained at once an acid of 48.45° B., and when the saltpeter was previously dried, even of 49.4° B. In addition to this he obtained an excess of yield, which must be ascribed to nitric acid contained in the waste acids.

An engineer in the Government powder works near Brest, where gun-cotton is manufactured, on obtaining information of these experiments, raised the objection that small quantities of gun-cotton might be present in these waste acids and give rise to explosions. Repeated experiments, made with large quantities of the waste acids, have, however, shown that after decanting and filtering there is no danger in the further treatment of these acids. (*Bull. Soc. Chim.*)

The *Sci. Am.* **56**, 180; March 19, 1887, states that a number of experiments were conducted lately at the works of Messrs. Heenan and

Froude, Manchester, with a new explosive called "Roburite," which is manufactured in Germany, and is about to be introduced into this country for use in blasting operations. The composition and process of manufacture of this explosive are kept secret, but we understand that it consists of two non-explosive and perfectly harmless substances of such a nature that they may be stored or transported without special precautions or restrictions. These two substances may be mixed together when required, and, in combination, become roburite, a yellowish compound, which will bear rough handling with safety. We understand that an intense heat is necessary to explode it. In order to prove this, the explosive was placed, in the experiments in question, between two plates, which were freely rubbed together and hammered; and a small quantity thrown upon a fire was merely consumed, without exploding.

In order to obtain an idea of the explosive effectiveness of roburite, eight ounces of the explosive were placed in the centre of a plate of the very best steel and exploded. This plate was 3 feet square by half an inch thick, and a bulge of about 1 foot diameter and 3½ inches deep was caused by the explosion. Twelve ounces of the explosive were then placed on a cast-iron plate, 6 inches thick, weighing nearly three tons. After the explosion the plate was found to be broken transversely. Unlike dynamite, roburite is said to be in no way affected by varying temperatures, and if duly protected against damp, it may be kept for years in any climate without its efficiency becoming in any way impaired. It is also claimed by the manufacturers that roburite has an explosive force greater than dynamite by at least 25 per cent.

In exploding, roburite does not produce noxious gases, and therefore may be used without intermission, while the poisonous gases given off by dynamite often necessitate the stoppage of work, in some cases for a considerable time. This new explosive is applicable for use in mines and quarries, and for torpedoes and blasting operations generally. (*Industries.*)

Under the title of "Unsuspected Dangers with Frictional Electricity in Blasting," W. E. Irich narrates, in the *Scientific American Supplement*, **23**, 9172; January 1, 1887, an incident which occurred some years ago, and which nearly resulted in a most serious calamity, through want of knowledge regarding the power of induction.

About a week after the commencement of a long series of experiments, several charges of gunpowder, gun-cotton, and dynamite were submerged in a river, about one hundred feet apart, the object being to learn what the effect of each would be when fired under the same conditions. The firing station and the position of the charges in the river were on this occasion totally obscured from each other, and about one mile apart. The cable employed to connect the charges with the firing apparatus consisted of a stranded copper wire well insulated with "Hooper's compound." Two lines were used for firing the charges, and a third or special cable of the same description was laid for communicating between the two points by telegraph. The three cables were laid on grassy land, parallel to but separated from each other by a space of a few inches throughout the greater part of their length. Electricity for firing the charges was obtained from Baron Von Ebner's ebonite-disk frictional machine.

The two ends of the cables at the river were each connected to a charge, while at the firing station one of the ends was carefully sealed and suspended in the centre of the firing room as a precaution and guard against the possibility of its coming in contact with the firing battery or machine. The other end was connected to the electric generator in connection with the charge to be fired first.

Final arrangements having been completed and all made ready, instructions were telegraphed to fire No. 1 charge, which was carefully and correctly done. Scarcely, however, had the firing key been depressed when word was wired from the river "to stop further operations, and leave everything at the firing station in the exact position it then occupied, as two charges had been fired instead of one only, as directed, and that in consequence a boat and a party of men engaged near the charge had most miraculously escaped being blown to pieces." This was declared by the operators at the firing station to be impossible through any action or neglect on their part.

The matter, however, was too serious to be left without a thorough and searching investigation. There was no question as to the second charge having been fired, and a careful examination of the cables between the points immediately after the occurrence failed to show the slightest sign of their having been tampered with. The evidence tended to locate the cause at the firing station, but how or by what means the charge was fired was quite unaccountable to all, and remained a matter of conjecture for several days, as the spare end of the cable had remained securely sealed and suspended, and was at the time of firing many feet away from the electric generator. A very careful examination and insulation test of the end of this cable in the firing station proved that it had not been injured or tampered with in any way.

Experiments and investigation led eventually to the discovery of the fact that the firing of the second charge was due to induction. To remove all doubt of this, and for the information of all concerned, two half miles of the same description of cable were placed one foot apart throughout their entire length, fuses being connected to the cables at one end to represent the charges, and the wire being then grounded as before. To one of the cables at the firing station the frictional machine was connected, while the other end was carefully sealed and suspended in the same room as before, and at least ten feet away from the generator. The disks of the machine were given twenty revolutions, and the condenser was discharged, when both fuses fired. Other tests were then made, as given in the following table, to discover the greatest distance through which this inductive action would fire a charge, the wires being arranged as described above:

Distance of cable apart in feet.	No. of revolutions of the disk.	No. of charges fired.	Distance of cable apart in feet.	No. of revolutions of the disk.	No. of charges fired.
6	20	2	20	30	2
3	4	2	30	30	2
3	4	1	40	30	1
9	20	2	40	30	1
12	20	2	40	40	1
15	10	1	40	50	1
15	20	1	40	50	1
15	30	2	35	50	1
20	30	2	30	50	2
25	30	2	30	50	2

It would be dangerous on cables running parallel, and within forty or fifty feet of each other, to employ the frictional machine where more than one charge is connected.

It will be seen from the above table that a charge connected with a cable, one end of which was insulated, could be fired by the inductive action of another cable running parallel to and separated from it by a space of thirty feet when one class of electric generator was employed, whereas with a different generator the second fuse was not fired even when the cables were tied or twisted together, as will be shown by the following tests:

The frictional machine was now removed, and tests were made with dynamo machines and voltaic batteries, but in no instance was more than one charge fired, even when the wires were as close together as it was possible to get them, and then it was the one connected in circuit with the machine or battery.

These experiments clearly show that the detonation of the primary charge fired was not the cause of the second one exploding, and that the action was due to induction only. Had it been due to detonation, both charges would have been fired as readily by a dynamo machine or voltaic battery as with the static machine.

This power of induction could be put to good use, particularly in naval warfare, in firing and destroying the enemy's mines. It may also be interesting to note that, with a thirty-cell Grove battery and similar cable to the above, he succeeded in firing through a fault made by stripping off twenty-four inches of the insulation and submerging the bare wires in the sea. With an induction coil he failed to fire through a fault in the insulation only sufficient to expose the conductor to the eye. Wheatstone's magneto-exploder fired the charge through a leak one twenty-fourth of an inch long, but failed through a fault exposing one-eighth inch of the conductor. Siemens dynamo machine fired the charge through a leak exposing a surface of three-tenths inch, but failed to do so with a larger fault. Von Ebner's frictional machine fired through a leak of four and a half inches of bare conductor. It also fired the charge through a perfect break in the conductor. A four-cell Grove battery fired through three-eighth-inch leak, but failed to do so through three-quarters inch.

In connection with this it may be interesting to note that *Nature*, **17**, 50–53; 1877, in an article on "Modern Torpedo Warfare," in reviewing the results of some experiments undertaken in Denmark two or three years before, briefly says: "Another point was also noted. A current of electricity, if it emanates from a powerful frictional electric machine, traversing one of a bundle of wires, will induce a current in the other wires, and thus bring about the explosion of torpedoes other than that which the operator on shore desires to ignite."

We observe that it is not stated in either of these two cases whether or not experiments were made to prove that the insulation between the wires was perfect.

F. Raschig, *Annalen*, **230**, 212–221; 1885, accounts for the discordant results of the analyses of iodide of nitrogen by Gladstone, *Jour. Chem. Soc.* **34**, 1851, Stahlschmidt, *Pogg. Ann.* **119**, 421, and Bunsen, *Annalen*, **84**, 1, by the fact that the precipitate obtained by adding ammonia water to a solution of the iodide is decomposed by washing with water. Sesqui-iodamine, NH_3,NI_3 or NH_2I,NHI_2, is first precipitated, but it is converted during the process of washing into NHI_2 and NI_3. The latter compound dissolves in potassium cyanide, forming cyanogen iodide: $NI_3 + 3KCN + 1H_2O = 3CNI + NH_3 + 3KOH$. The iodide of nitrogen prepared from a solution of iodine differs in its properties from the iodide obtained from the action of ammonia on finely divided iodine. The latter compound is much more explosive than the former, as it is capable of exploding when moist. The composition of this substance has not yet been ascertained.

By reference to the *American Chemical Journal*, **1**, 4–9; 1879, it will be found that J. W. Mallet has already gone over the ground which Raschig has been reviewing, that he has pointed out precisely the same source of error in the work of previous investigators, and that he has determined the composition of the amide produced by the action of ammonia on finely divided iodine and which was explosive under water, and he found that when it was produced with great care at a temperature below 0° C., and by the use of the strongest ammonia water and well purified by washing with ether and alcohol, it had a composition corresponding to NI_3 or N_2I_6, but with weaker ammonia hydrogen was found in the amide.

Mallet proposes to use the higher formula in view of the general fact that the compounds of nitrogen in which this element behaves as a pentad are those in which instability is chiefly observable, and from noticing the proportions in which hydrogen and iodine have been found in these amides it seems fairly probable that the molecules of these explosive compounds contain two pentad atoms.

T. Klobb, in studying "The Compounds of Ammonia with the Metallic Permanganates," *Compt. rend.* **103**, 384; Aug. 1886, finds that a permanganate of silver and ammonia ($Ag_2Mn_2O_8.4NH_3$) may be formed by dissolving one equivalent of potassium permanganate in water at 10° C., saturating with cold ammonium hydroxide, and adding two equivalents of silver nitrate dissolved in ten times its weight of water. A crystalline precipitate is formed at once which, when washed and dried, has the form of a violet powder, and is but little soluble in cold water, though more soluble in warm. It slowly decomposes on exposure, losing ammonia and leaving a solid residue. Heated brusquely it fuses and is decomposed. It detonates under the blow of a hammer.

The cobaltic dodecammonium permanganate $[CO_2](NH_3)_{12}(Mn_2O_8)_3$ is deposited as a black crystalline powder when concentrated solutions of one equivalent of luteocobaltic chloride and three equivalents of potassium permanganate are mixed. When dissolved in boiling water it crystallizes out on cooling in small brilliant black crystals having the form of cubes, octahedra, and modifications of these two. When these crystals are heated or struck they detonate.

As a result of further study of the "Diazo-compounds," P. Griess, *Berich. Berl. Chem. Ges.* **19**, 313–320; 1886, has succeeded in producing a number of triazo and tetrazo compounds. Among these is the metatetrazo benzene platinum chloride having the formula $C_6H_4.N_2(NCl)_2.PtCl_4$. This crystallizes in very small roundish yellow plates, nearly insoluble in cold water and alcohol, but decomposed with evolution of nitrogen when heated with these liquids. The dry salt explodes violently when heated. The gold chloride $C_6H_4.N_2(NCl)_2.2AuCl_3$ is obtained as an explosive precipitate consisting of microscopic yellow needles. These salts resemble the diazo compounds in their reactions.

R. Möhlau, *Berich. Berl. Chem. Ges.* **19**, 280–283; 1886, prepares "Nitrosophenol Hypochlorite" by dissolving 1 gram of nitrosophenol in 500 cc. of water, adding 5 cc. of hydrochloric acid, and then running in a solution of bleaching powder until a distinct odor of hypochlorous acid is observed. It crystallizes in slender yellow needles having the formula of $C_6H_4NO_2Cl$, explodes when quickly heated to about 70°, or when touched with a drop of strong sulphuric or nitric acid, and gives Liebermann's reaction. It reacts energetically with amines and phenols, is resolved into nitrosophenol and hypochlorous acid by alkalies, and when heated with dilute sulphuric acid is decomposed into quinone, hydroxylamine, and hypochlorous acid. Acetophenonoxime also unites with hypochlorous acid.

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

MAY 16, 1887.

PROFESSOR N. M. TERRY, PH. D., Head of the Department of
Physics and Chemistry, U. S. Naval Academy,
in the Chair.

ELECTRIC MOTORS.

By F. J. SPRAGUE (Late Ensign, U. S. N.).

Commander W. T. SAMPSON, Vice-President, in the chair.—The subject of the paper to be presented to the Institute this evening is "Electric Motors," and the lecturer, Mr. Frank J. Sprague, formerly an officer of the Navy and a graduate from the Naval Academy in 1878.

It is but a short time since Mr. Sprague was a student in this laboratory,* and I recall with much satisfaction the interest he always manifested in the subjects taught in the department of Physics and Chemistry. He was always among the leading men in his class in all branches; it was here that he passed his otherwise leisure hours and often his Saturday afternoons. Although his success in the scientific work which he has adopted as his profession is due to his ability and untiring energy, yet, no doubt, his first taste for it and his first successes in its pursuit were acquired here.

The same may, doubtless, be said of a number of other graduates of the Naval Academy who have already attained places of distinction in the scientific world.

I can imagine that it must be a source of gratification to Mr. Sprague to stand in this lecture hall and instruct those who were once his teachers. Though it is not among the substantial rewards of his success, it is well calculated to satisfy a commendable ambition.

Prof. N. M. Terry, head of department of Physics and Chemistry, will preside during the lecture and discussion.

* The meeting was held in the Lecture Room of the Physical Laboratory, U. S. Naval Academy. —ED. COM.

Mr. Chairman and Members of the Institute:—In extending my thanks to you for assembling to hear some remarks on a subject of such new and growing interest as that of electric motors, I feel somewhat at a loss how to proceed, because the subject admits of such a variety of treatment. Feeling thus, I have come to the conclusion that perhaps I had better speak of the subject from the standpoint of my own personal experience and practice. I will try to set forth, at first, some of the simpler laws governing the construction of motors and operation of motors, then touch upon the general question of the transmission of power, and, finally, speak of the present and future development of this work.

If some of the truths seem too familiar, I beg you will bear in mind the absolute necessity of fully understanding their fundamental character, and the importance of always referring to them as a basis, if we would correctly explain the operation of a motor, or forecast its operation with any certainty.

In any part of an electric circuit the expenditure of energy is measured by the product of the current and the extreme difference of potential, or $W = CE$.

If this energy is partly expended in heat and partially recovered in useful work, we have the expression

$$W = w + HJ,$$

where H equals the heat lost per second, and J Joule's equivalent.

But if R equals the resistance of the circuit,

$$HJ = C^2R,$$

and we have
$$W = w + C^2R,$$

or
$$w = W - C^2R.$$

If an opposing electromotive force e exists, which in the transmission of power is the motor electromotive force, commonly called the counter electromotive force, it is evident that

$$C = \frac{E - e}{R}.$$

Hence
$$W = E\left(\frac{E - e}{R}\right).$$

Substituting the values of C and W, we have

$$w = E\left(\frac{E - e}{R}\right) - \left(\frac{E - e}{R}\right)^2 R,$$

or
$$w = \frac{E - e}{R}\left[E - (E - e)\right],$$

or $$w = e\,\frac{E-e}{R};$$

and we also have the ratio

$$\frac{w}{W} = \frac{e\left(\frac{E-e}{R}\right)}{E\left(\frac{E-e}{R}\right)} = \frac{e}{E}.$$

That is, the electrical efficiency of the circuit is the ratio of the motor electromotive force to the generator electromotive force, or of the counter to the initial.

All the energy which is delivered to the motor is expended in two ways—heat and work. Our object should be to have as little as possible in heat; as much as possible in useful work. The current which goes into the field magnets serves to excite them, but the current thus used in maintaining the lines of force in the field magnets may be expressed simply as waste heat, and is measured by the quotient of the square of the electromotive force by the resistance of the field coils. The current that flows in the armature is expended partly in heat. This is measured by the product of the square of the current and the resistance of the armature; hence the resistance of the armature should be as low as possible. All the rest of the energy of the current is expended in work. This work appears in three forms. One is driving the armature in the magnetic field and forming currents in the body of the armature, and will be greater or less according to the formation of that body. Another expenditure of this work is the overcoming of friction of the armature bearings. The third is useful work.

Two distinct theories have been advanced for the proper construction of motors. The one is advocated by Messrs. Ayrton and Perry, and is to the effect that different general principles should govern the construction of dynamos and motors: that in the former the field moment should greatly predominate over that of the armature, while in motors the moment of the armature should greatly predominate over that of the field.

On the other hand, Professor Rowland, Dr. Hopkinson, Messrs. Mordey and Kapp, and I, hold the opinion that the best apparatus for converting mechanical power into electricity must necessarily be the best apparatus for converting electricity into mechanical power, and that the principles governing the electrical construction of one must be also the best for constructing the other. In short, in motors as well as in dynamos, we should aim to have the most intense magnetic field possible, and the greatest ratio between the magnetic moment of the field and armature which the construction of the machine will permit. It is true that the great varieties of work demanded of motors make their construction often different from dynamos, but this does not affect the truth of the principle involved. So many practical as well as theoretical reasons exist for this view that I cannot see how any doubt can long exist of its soundness, and the fact exists that the most extensive and numerous developments of the transmission of power are made on these lines. Some of the reasons for adopting this view will appear as I proceed.

A motor when running may be considered as a dynamo machine propelled by a current: it has a field magnet like any other dynamo; it has an armature situated in that field, which, either because of the attraction and repulsion of the lines of force, or of the double attraction and repulsion of the poles which are set up in the armature acting on the poles of the field magnet, is caused to rotate. This armature rotating in the magnetic field has an electromotive force developed in it which is precisely of the same kind as would be developed were the motor driven by a belt instead of by a current. The strength of this electromotive force depends upon the resulting strength of field and the speed of the armature. This electromotive force, which may be termed a *motor* electromotive force, is ordinarily called the counter electromotive force, because it is opposed to that of the line current which is flowing into the motor. The difference between this line electromotive force and that of the motor is termed the effective electromotive force, and determines, in combination with the resistance of the circuit, the strength of current which will flow in the circuit.

As I have stated, the province of the field magnet is to produce lines of force which shall pass through the armature. Since this is the fact, it is apparent that we wish to create as many lines of force as possible in the smallest space, with the least weight of metal and with the least expenditure of energy.

In considering, however, the way in which the lines of force can be created, we must take into account a great many elements. One is the character, mass, shape, and distribution of the iron which is used in the cores of the field magnets and in the pole pieces. Another is the mass, space, and distribution of the wire around the magnets. Not less important is the character of the armature body, the space taken up by the wire, and clearance outside of the wire. This magnetizing force is represented by the product of the turns of wire and the number of ampères flowing in these turns—in other words, by the ampère-turns; and it is absolutely immaterial, so far as the magnetic result is concerned in the creation of the lines of force, how this product is made up—that is, whether there are a few turns and a great many ampères, or a great many turns and few ampères. For instance, if it takes ten thousand ampère-turns to magnetize a field magnet to a proper degree, we can magnetize it with one turn of wire and ten thousand ampères, or one ampère and ten thousand turns.

When we consider the economy, however, then we wish to have the greatest number of turns and the least number of ampères. In the case cited, if we used ten thousand ampères and one turn, we would be using ten thousand times the energy to magnetize the field magnets which would be expended were we to use ten thousand turns and one ampère.

That form of iron which gives the least length of wire for one turn is of course the circular, and that is the form which I have adopted in the field magnets of most of my machines. When exciting a field magnet from lines of given difference of potential, the ampère-turns which will flow is dependent upon the cross section of the wire alone, provided the mean length of turn is not changed. In other words, if the field magnet is wound with a certain gauge of wire it does not make any difference, so far as the strength of the field is concerned, whether there be simply one turn of the length of say two feet, or whether there be ten thousand turns each of the length of two feet, because just as we increase the number of turns we increase the resistance and we decrease the current, but we leave the product ampère-turns, which we will call Z, the same. Economy, however, as I have said, determines that we shall use the largest number of turns which we can place practically in a given space on our field.

Having, then, determined the magnetizing force, we have next to consider what opposes the creation of the lines of force. In some very beautiful experiments made by Dr. John Hopkinson and published in a communication to the Royal Society of London, some elaborate tables were given, illustrated by a number of curves, which showed the magnetic property of about thirty-five specimens of iron and steel, and the strength of field magnets for different magnetizing forces. It was there shown that the best material for commercial purposes to be used in field magnets was pure wrought iron annealed, because it offered less opposition to the creation of lines of force than any other material. This had been practically accepted as a fact before the publication of these experiments, but I know of none which are entitled to more consideration. The introduction of manganese, sulphur, silicon, phosphorus, or carbon means very radical changes in the qualities of the iron, more so than has generally been realized.

We may make some analogies between magnetic and electric circuits. The magnetizing force or the ampère-turns may be likened to the electromotive force which urges a current over a circuit. As in an electric circuit the current generated depends upon the resistance of the circuit as well as the electromotive force, so too in the magnetic circuit may we very properly consider that the formation of lines of force actually created depends also upon the resistance of the path. The resistance of this path depends upon not only the cross section of any space over which the lines of force have to pass, whether in the metal or in the air, but also upon the specific resistance per unit cross section of the material over which they pass, this being different for cast or wrought iron, and being very much higher than either for air. It also depends upon the length of the space. We would then suppose that the number of lines of force which are created would be the quotient of the magnetizing force by the resistance; but when we come to magnetize a mass of iron, we find that a totally different element comes into play, and this seems to be a force which we may liken, if you please, to a counter electromotive force in an electric circuit—that is, it is an opposition set up to the formation of lines of force, which increases with the degree of magnetization, and finally reaches such a point that it effectually bars any further increase of this magnetization. In other words, if we plot out, as was first done by Mr. Hopkinson, the characteristic of a field magnet, laying off as ordinates the number of lines of force created, and as abscissae the magnetizing forces, we have a curve which starts almost as a straight line from the origin at an angle to both the axes of x and y, but soon begins to curve and finally becomes almost parallel to the axis of x, or so lightly inclined to it that it becomes a straight line which would intercept the axis of x at a long distance to the left of the origin. This has been explained by considering the curve to be formed of two components, one expressing the lines of force due to the presence of the iron, and the other additional lines of force set up by the coils around the iron; that the first part of the characteristic curve is formed by the sum of the ordinates of both, and the latter part of it simply by a slowly increasing ordinate expressing magnetization due to the coils around the iron.

I do not feel prepared here to say whether this theory is right or not. If the iron can be brought up to a certain saturation and not be increased any more, then it seems that the air surrounding the conductor may be brought up to a degree of saturation and no further saturation possible. If this is so, it follows that we would finally reach a point in the characteristic curve of either a mass of iron or coils of wire, or these combined, when it would become tangent to the axis of x, and no further increase of magnetization would be possible under any circumstances. Physical conditions, however, prevent our reaching this point, because before we would get to that we would burn the coils off our field magnet because of the great heat developed. It follows that with every different shape of field magnet, quality of iron, and distribution of mass, that an empirical formula must be derived to truly express the conditions of magnetization.

To express a value for the number of lines of force, we must in addition consider the inter-polar space. This is occupied by the mass of iron in the body of the armature, which ought to have at least the cross section of iron that is present in the core pieces of the magnet; and it is further important that the space taken by the coils of wire on the field magnet should be just as small as possible. In other words, the gap or space between the pole faces and the body of iron of the armature should be as short as possible because of the very high specific resistance of air.

Mr. Siebert Kapp, in a very excellent book on the electric transmission of energy, has given some formulas for dynamos and motors of wrought and cast iron, and of different forms. But, as he has pointed out, they apply only to low degrees of magnetization, and of course depend upon the quality of iron used.

Although the quality and dimensions of the iron masses in a motor are important, it will be found in practical experience that the resistance of the gap is a no less important feature, and I will cite an illustration showing the important bearing which it has on the construction of a machine. As I have stated, I differ radically from Messrs. Ayrton and Perry in the theory which should govern the construction of a motor. I have said the field magnet ought to be as intense as possible; that is, the greatest number of lines of force should be created that it is in our power economically to produce. The resistance of the armature should be as low as possible, and the magnetization of the armature should also be as low relatively to that of the field magnet as possible. Suppose that a machine has wound on its armature four layers of wire, and that it has a further space for clearance equal in depth to the thickness of one of these wires. The total gap then may be said to be $5a$, a being the thickness of one wire. *The magnetic moment of this armature with any given radiation of heat per square inch of surface is fixed, no matter how it may be wound, and no matter what its power.* This magnetic moment is, of course, the product of the ampères by the turns of wire. Suppose, for example, this armature be stripped and then wound with one-half the turns of wire, the wire being of double the cross section of that first used. We will assume that the insulation always bears the same ratio to the cross section. The armature would now have one-fourth the resistance, one-half the number of turns, it would carry double the current, the heat radiated per square inch of surface would be the same, the speed would be doubled, the power would be doubled, but the ampère turns would be a constant; and so on in other proportions. Suppose, on the other hand, that the armature be intended for a certain horse power, and have a certain radiating surface, it would, with a given efficiency, have a certain resistance. With this fixed resistance, the cross section of the wire would be in direct proportion to the number of turns. Instead of using eight turns of a certain cross section, laid four deep, suppose we use four turns, keeping the resistance the same. The cross section of the wire would be one-half. The weight of the wire would be one-fourth. The room occupied by the wire would be one-fourth. The capacity of the machine would be the same. The heat radiated with any given current would be the same. The gap would be reduced in the proportion of 5 to 2, assuming that we leave the same clearance. Since, however, we use a lighter wire, we can use a smaller gap, because, having less weight, the wires will have less centrifugal force and a finer binding wire can be used. We have then this new condition of affairs: the resistance of the armature has remained constant; the heat-radiating surface constant; the capacity of the armature constant; the weight of the copper in the armature has been reduced 75 per cent; the number of turns has been halved; the gap has been reduced 60 per cent. If, now, our field magnet was not nearly saturated, the number of lines of force which appear will be about doubled, because of the reduction of the gap; and since the lines of force have been doubled, the counter electromotive force which is set up by the armature at the same speed will be the same, although there are only one-half the turns of wire that we had in the first place. The magnetic moment of the armature will be one-half what it was. The strength of the field being doubled, it follows that the ratio between the magnetic moment of the field and of the armature will have been quadrupled. There will be less distortion of the lines of force, there will be less sparking at the commutator brushes, there will be less change of lead at the commutator brushes. In addition to this, we have double the strength of field without increasing the expenditure of energy in the field magnet; in short, we see that one of our main objects should be to make with the most intense magnet field the smallest possible gap, taking care, however, that the increase of lines of force which we desire will be obtained by the proper proportion of the gap and the energy expended in the field magnet coils.

One of the most instructive experiments, showing the value and importance of masses of iron in both the field and armature of a motor, is the following: Arrange the motor with a balanced lever of known length attached to the armature shaft, with accurate means of reading the pull in a direction strictly tangent to the circumference of the circle which would be described by the end of the lever. With fixed strengths of current in the field, vary the current in the armature by any of the ordinary controllable means, and take simultaneous readings of the pull. This will give a curve showing the *characteristic of the armature*, which is just as important as that of the field. Then, with known currents in the armature, vary the current in the field, and likewise note the current and torsion readings. These results will give a saturation curve of the field, and an investigation of the data will give some interesting facts about your machine.

Several years ago Professor Moses G. Farmer suggested that I would find it an interesting investigation to determine a characteristic of the effective strength of field magnets by determining the number of feet per second a conductor one foot long would have to move to develop an electromotive force of one volt at its terminals when moving in the active part of the field. I use this method continually in my investigations, and have deduced for this purpose the following formula for the Siemens form of armature:

$$\varphi = p \frac{b \times l \times d \times t \times r}{2750 \times v},$$

where $b =$ number of blocks in the commutator.
$l =$ length in inches of active part of pole pieces of field.
$d =$ mean diameter in inches of the circle of revolution of a coil.
$t =$ number of laps of wire in one coil.
$r =$ number of revolutions per minute.
$p =$ ratio of circle covered by the pole pieces.
$v =$ total e. m. f.

Motors may be described as belonging to one of three different systems. First, those in which the field magnet is excited by a coil in parallel circuit with the armature; second, those in which the field magnet is in series with the armature circuit; and third, those in which there is a combination of these two circuits. There are in addition a very large variety of each of these classes, different conditions demanding different performance. Furthermore, similar machines may be placed upon three different kinds of circuits, their performances varying widely in each case. These three conditions are: First, the case of special transmission with varying potential and current; second, constant current circuits; and third, constant potential circuits. I will now briefly consider the action of these different kinds of machines on two classes of circuits: First, on the constant current circuit. If a series-wound machine be placed upon such a circuit, the same current passing through the field magnet, it will develop a constant torque, which torque is directly proportional to the strength of the field magnet and the armature. If the masses of iron are large, this torque will be directly proportional to the effective ampère-turns in the field magnet, and the work done will be directly proportional to the speed. If the machine be at rest there will exist a difference of potential at the terminals of the machine equal to the product of the current and the resistance of the machine. When running, however, an electromotive force will be developed in the machine, and the potential at the terminals of the machine will rise by this increment. The work done may be expressed by the product of this counter electromotive force and the current, or eC, and is independent of the resistance of the machine. The resistance, however, determines, in combination with the other elements, the total efficiency of the motor. The total energy expended is the product of the difference of potential existing at the terminals of the motor and the current flowing, or EC. The efficiency then is $\frac{eC}{EC}$, or $\frac{e}{E}$, and the heat wasted $(E-e)C$.

When running at any particular speed, the work will be increased directly as the field magnet strength is increased. So also will be the economy. The heat waste with any given resistance in a machine under these conditions is constant. The direction of rotation of such a machine can be reversed by reversing either the armature circuit or the field circuit; if both circuits are reversed, then the machine will run in the same direction. For many classes of work this kind of machine is exceedingly useful, because it admits of a great range of hand control. If such a machine, however, be put on ordinary work, and this work be lightened up, the machine will run faster and faster, and unless the field is weakened or the brushes are shifted to check it, the speed will theoretically increase without limit. Every change of speed and every change of load is accompanied by a corresponding change in the potential which exists at the terminals of the machine. Moreover, on a constant current, the motors being in series with each other and with lamps, this continual variation of potential is apt to cause trouble on the circuit, especially if the machines are not automatic, since, as already stated, with any fixed field the torque is constant, the work done is directly proportional to the speed. The machine has the highest efficiency when running at the highest speed.

With shunt machines, however, the action on the constant current circuit is much different. Here the current is divided in two circuits, such division, when the motor is at rest, being inversely proportional to the resistances of the two parts of the circuit. With such a motor, the field is weakest when the machine is at rest, and its torque or rotary effort is also very weak. As the speed of the machine increases a counter electromotive force is set up, the potential at the terminals of the armature and field magnets rises, the current in the armature diminishes, and that in the field magnet increases.

There are two ways by means of which a constant current motor can be governed. One consists in automatically changing the counter electromotive force by changing the position of the brushes on the commutator to positions more or less removed from their normal one. To this objection is offered because the proper position for the brushes of any machine is at the points of least sparking. The other method consists in varying the counter electromotive force by automatically weakening the field as the load is diminished, or strengthening it as the load is increased. Several methods have been proposed for doing this, generally by the action of a centrifugal governor, but I am now engaged on another system which promises better results.

On constant potential circuits the different classes of motors present other peculiarities. A plain series-wound motor, when there is sufficient iron in the field, has a torque proportional to the square of the current flowing through it. It is capable of exerting a great rotary effort and doing a large amount of work at a slow speed. The range of speed for different loads is, however, great, and the motor is entirely unfitted for ordinary work where steadiness of speed is an object; as the load is diminished the speed increases, and, if thrown off entirely, the motor will run faster and faster, the field continually growing weaker, and the armature all the time accelerating its speed in a vain attempt to generate an electromotive force equal to the initial.

A series motor has some excellent characteristics for work where great changes in speed and torque are desired automatically, these changes being varied inversely.

Since with any given strength of field the torque varies with the increase in the strength of the armature field, and with any given strength of armature the torque varies with the increase in field strength, it follows that with large masses of iron in the armature and field, the torque will vary with the square of the current, and the ratio between the field and armature moment will remain constant.

The following will show the law of variation of speed for a series motor within the limits of the straight line saturation on a constant potential circuit.

If R is the resistance of the armature, and f that of the field, then

$$C = \frac{E - e}{R + f}.$$

$$\text{Work} = e\,\frac{E - e}{R + r} = eC.$$

Work also equals speed multiplied by torque.

The ampère-turns in the field $= nC$. e must vary, then, directly as speed and the field strength; whence

$$\text{Speed varies as } \frac{e}{nC} \text{ or } \frac{e\,(R + f)}{(E - e)\,n},$$

that is, the speed varies directly as the motor e. m. f., and inversely as the effective e. m. f. or current.

But the torque varies as nC^2 and equals MnC^2, M being some constant. Hence we have: Work $=$ Speed $\times MnC^2 = eC$,

$$\text{or Speed} = \frac{e}{MnC};$$

but

$$e = E - C(R+f),$$

whence

$$\text{Speed} = \frac{1}{Mn}\left[\frac{E}{C} - (R+f)\right]$$

so long as the characteristic is a straight line.

On the other hand, the shunt-wound machine will run fairly well on a constant potential circuit. The field, being excited independently of the armature, is constant, and since the load varies with the motor electromotive force, and the field is constant, it follows that the speed must vary with e. The torque is proportional to the current in the armature, and the speed will be slowest with the greatest load and fastest with the lightest, that is, when $e = E$. The lower the resistance of the armature, the less the variation in speed, and if sufficiently low with a large ratio of magnetic moments, the motor will practically run at a constant speed.

It is with the third class of motors, when used on constant potential circuits, that the difficulties which are involved in the governing of a motor mostly disappear, and, without the use of any such apparatus as centrifugal governors or movable contacts, it becomes possible to satisfy the most exacting conditions, both as regards efficiency, steadiness of running, power to start under very heavy loads, and freedom from sparking.

I must now particularly request your attention to a seemingly paradoxical statement. In a motor with the armature and field magnet independently supplied, the work which the motor will do in a given time, its economy and efficiency, are all independent of the strength of the field magnet, provided the translating devices intermediate between the motor and whatever is the recipient of its motion are not limited as to the rate of transmission of the motor speed; and that in all cases where a motor is working on a constant potential circuit and not up to its maximum capacity, *but still above fifty per cent armature efficiency*, in order to increase the mechanical effect either of speed or power, or both, or to compensate for any falling off of the potential on a line, it is necessary to weaken the field magnets, instead of strengthening them, and vice versa.

The strength of the field determines the speed at which a motor must run to get a required efficiency. With a given initial potential at the armature terminals, no matter how the load varies from the maximum allowed, the speed may be maintained constant by changing the strength of the field; such strength being diminished as the load is increased, and, vice versa, increased as the load is diminished.

These facts may be demonstrated as follows:

Let us consider the motor current as derived from mains having a fixed difference of potential, and the motor with its field and armature in shunt relation. In this case the armature runs with a velocity dependent upon the strength of field, the initial potential, the number of turns, resistance, etc., of the armature, and the load, and a counter electromotive force is set up which regulates the armature current. The higher the speed the greater this counter electromotive force. Let E be the initial and e the counter electromotive force, and r the resistance of the armature. The current flowing in the armature is then $\frac{E-e}{r}$. With a given armature and given field, e varies with the speed. The power at any given speed and strength of field varies with the current, and with any given current varies with the strength of field. The total work done is the product of the speed by the work per turn, and since the speed is as e and the work per turn as the current $\left(\frac{E-e}{r}\right)$, the total work done is expressed by $\frac{e(E-e)}{r}$. The efficiency is the ratio $\frac{e}{E}$. It will be seen that both these expressions—the total work done and the efficiency—are independent of any function of the field, but depend only on the initial and counter electromotive forces and the resistance of the armature, for any given value of e can be attained with any strength of field by attaining proper speed.

Considering the speed of machine constant, its field alone being varied, and differentiating the expression for work done, $\frac{e(E-e)}{r}$, we have $\frac{de}{r}(E-2e)$ as the rate of variation of work, which will have a positive value with de negative when e is greater than $\frac{E}{2}$.

It follows, then, that to maintain the speed constant with a current of constant potential under varying loads, when the load increases so that the speed would naturally decline, the field must be weakened, the counter electromotive force diminished and armature current increased, so that the tendency to reduced speed shall be counteracted, and there shall be an increase in the mechanical effect—power. For a decreased load the field is strengthened, the counter electromotive force increases, the current decreases, the speed remaining the same.

To maintain speed or power constant under varying initial potential, if the potential at the motor terminals increases, these mechanical effects increase or tend to increase. By strengthening the field an increased counter electromotive force is produced, so that the increased power or speed, or the tendency thereto, is counteracted, and this counteraction may evidently be itself considered a decrease in mechanical effect, whether the regulation is performed simultaneously with the increase of potential or before or after such increase. If the regulation is performed simultaneously, with a gradual change of potential, there may be less change in counter electromotive force or armature current; but there is still the counteracting of the tendency to increased mechanical effect, which counteracting is itself a decrease of mechanical effect. For a decreased or decreasing initial potential, the field is weakened to counteract the decrease in mechanical effect which would otherwise occur, and therefore to produce an increased mechanical effect.

Hence, to change the speed or power of a motor on a circuit of constant potential, the speed or power is increased by weakening the field, which produces a decreased counter electromotive force and an increased armature current, and consequently the increased mechanical effect desired; and such mechanical effect is decreased by strengthening the field, and thus increasing the counter electromotive force.

In brief, then, this method of regulating shunt-wound motors consists in strengthening the magnetizing effect of the field magnet coils of the motor to decrease the mechanical effects, such as speed or power, or both, and vice versa, weakening such magnetizing effect to increase the mechanical effects, and under varying loads the speed is maintained constant by an inverse varying of the strength of the field magnet strength.

This may be accomplished in several ways, one by varying the field circuits by a mechanical governor which responds to any variation in the speed of the motor, or in hand-controlled devices. For automatic work, however, I prefer to make use of certain coils in series with the armature and dependent upon it, which coils have a resultant magnet action which is opposed to that of the main coils of the machine. While the main principle is the same, I have a number of different ways of applying it which may be classed as the long shunt, the short shunt, the distorted differential with long and short and compound shunts, and the distorted cumulative-differential with long and short and compound shunts. The first of these was originally proposed by Professor Ayrton, but the proportion of his winding was not the same as my own, because determined experimentally and with field magnets whose magnetic moment was less than that of the armature, while in my motors the converse is true.

In the following demonstration, then, it is to be assumed that the field moment greatly predominates over that of the armature, and also that the characteristic is practically a straight line.

Let f denote the resistance of the main or shunt field coils; m the number of turns therein; r the resistance of the differential or series field coils, and n the number of turns; E the difference of potential at the shunt terminals; e the counter electromotive force set up in the armature; and R the resistance of the armature.

The work done $= e\frac{E-e}{r}$; that is, it depends upon e, a variable quantity, and upon the constants E and r.

Now e varies with the speed and field, or the effective magnetic moment of the field, but the conditions are that the speed remains constant, hence e must vary with the field alone.

Current in shunt field $= \frac{E}{f}$;

Magnetic moment of same $= m\,\frac{E}{f}$.

Current in series field $= \frac{E-e}{R+r}$;

Magnetic moment of same $= n\,\frac{E-e}{R+r}$.

The effective magnetic moment must then be $m\frac{E}{f} - n\frac{E-e}{R+r}$; and the conditions are such that (for two different counter electromotive forces or two different loads)

$$\frac{e}{e^1} = \frac{m\frac{E}{f} - n\frac{E-e}{R+r}}{m\frac{E}{f} - n\frac{E-e^1}{R+r}}$$

or,
$$\frac{e}{e^1}=\frac{mE(R+r)-nf(E-e)}{mE(R+r)-nf(E-e^1)}$$

or,
$$\frac{e}{e^1}=\frac{mE(R+r)-nfE+nef}{mE(R+r)-nfE+ne^1f}$$

or, $emE(R+r)-enfE+ene^1f=e^1mE(R+r)-e^1nfE+e^1nef.$

Cancelling, we have

$$em(R+r)-enf=e^1m(R+r)-e^1nf,$$

or,
$$m(R+r)(e-e^1)=nf(e-e^1),$$

or,
$$\frac{m}{n}=\frac{f}{R+r}.$$

That is to say, the number of turns in the shunt coil must bear the same ratio to the number in the series coil as the resistance of the shunt coil bears to the sum of the resistance of the series coil and the armature.

This is my method of winding for a machine of the kind mentioned, and so wound it will be self-regulating for any constant potential up to the maximum allowed by the construction of the machine, and from no load up to the maximum.

There is a feature of motors so wound which may be here noticed. The ratio of the magnetic moments of the shunt and series fields is

$$\frac{m\frac{E}{f}}{n\frac{E-e}{R+r}},\text{ or }\frac{mE(R+r)}{nf(E-e)}.$$

But
$$\frac{R+r}{f}=\frac{n}{m}.$$

Hence the above ratio $=\dfrac{mEn}{mn(E-e)}$, or $\dfrac{E}{E-e}$.

That is, the ratio of the initial to the effective electromotive force is the same as the ratio of the moments of the shunt and series coil.

When $e=0$ this ratio becomes $\frac{E}{E}=1$; that is, the moments are equal, and this means that, in a perfect machine, *if both coils be closed and in their normal position, for any potential or current, a zero field, or practically so, will be formed, and the motor will either not start at all, or if it does start will run at a very great speed, take the maximum current at any given potential, and do little or no work at all.*

In starting, then, it becomes necessary to cut out this governing coil, making the motor a pure shunt motor, or to reverse it and make it a cumulative motor. I use both methods.

What has already been pointed out may be again stated, that the motor will regulate itself perfectly for all potentials so long as we work with a straight line characteristic, *but it must be with a theoretical armature efficiency of not less than fifty per cent, for if we go below this, the governing coil works in the wrong direction.*

A better way of arriving at this same law is as follows:

When running absolutely without load the motor e. m. f. is E, and the field is that due to the shunt coil. When running with a load the motor e. m. f. is e, and the magnetic field that due to the difference of the shunt and series field moments. We have then, since we assume that our speed is not changed, the equation

$$\frac{e}{E} = \frac{\text{shunt moment} - \text{series moment}}{\text{shunt moment}},$$

or, subtracting each side from unity, we have

$$\frac{E - e}{E} = \frac{\text{series moment}}{\text{shunt moment}}.$$

That is, the effective e. m. f. is to the initial e. m. f. as the moment of the series coil is to that of the shunt coil.

But

$$\text{series moment} = \frac{E - e}{R + r}\, n,$$

and

$$\text{shunt moment} = \frac{E}{f}\, m,$$

whence, substituting, we have

$$\frac{E - e}{E} = \frac{\frac{E - e}{R + r}\, n}{\frac{E}{f}\, m}\,; \text{ or, } \frac{m}{n} = \frac{f}{R + r}.$$

Referring to this equation, we see that if a is the resistance of one mean turn of the shunt coil, and b that of one mean turn of the series coil, then $n = \frac{R}{a - b}$.

By varying a, and n to correspond, then the motor may be set to run at different determined constant speeds.

Now consider the same class of motors with constant speed, varying load, and *constant current.*

Let the resistances and turns be designated as before. Let K be the constant current. Let E be the variable potential at the terminals of the motor, and e the variable counter electromotive force.

The work done $=\frac{e(E-e)}{R+r}$.

We must eliminate E, making it dependent upon e and the constants R, r, f, and K, and hence the work can be expressed in terms of R, r, f, K, and e, of which e is the only variable quality; e depends upon speed and field, but speed is constant. Hence our conditions require that with the same current we make e, and hence the work, variable, but by changes in the field alone.

$$\text{Field current} = \frac{E}{f}.$$

$$\text{Armature current} = \frac{E-e}{R+r}.$$

But $K=\frac{E}{f}+\frac{E-e}{R+r}$,

or, $$f(R+r)K=E(R+r)+fE-fe;$$

or, $$f(R+r)K+fe=E(R+r)fE;$$

or, $$\frac{E}{f}=\frac{(R+r)K+e}{R+r+f}, \text{ and } K-\frac{E}{f}=\frac{fK-e}{R+r+f}.$$

Moment of shunt field $=m\,\frac{(R+r)K+e}{R+r+f}$.

Moment of series field $=n\,\frac{fK-e}{R+r+f}$.

Effective moment $=\frac{m(R+r)K+me-n(fK-e)}{R+r+f}$.

Our conditions are such that

$$\frac{e}{e^1}=\frac{m(R+r)K+me-n(fK-e)}{m(R+r)K+me^1-n(fK-e^1)},$$

or, $$em(R+r)K+mee^1-nfKe+nee^1= \\ e^1m(R+r)K+mee^1-nfKe^1+nee^1.$$

Cancelling and transferring,

$$m(R+r)(e-e^1)=nf(e-e^1),$$

or, $$\frac{m}{n}=\frac{f}{R+r},$$

which is the same law as found for constant potential.

The ratio of moments is $\frac{m(R+r)K+me}{nfK-ne}$.

When $e=0$ this becomes $\frac{m(R+r)}{nf}$.

But $\frac{R+r}{f}=\frac{n}{m}$; hence substituting we have $\frac{mn}{nm}=1$.

That is, if the motor is at rest and any current is sent through it, a zero field will be produced. This of course follows from what has been already said about the constant potential motor.

The potential E which will exist if $e=E$ and no current is passing in the armature is fK, and the maximum work is done when $e=\frac{fK}{2}$. To be self-regulating, the motor can be worked up to this point, but not beyond it, for then the regulating coil works in the wrong direction; but this method of regulation is useless for constant current circuits, as is evident from the low efficiency.

We will consider another variety of motor in which this series coil is placed outside the terminals of the shunt coil. The laws governing the action of this machine on a constant potential circuit may be deduced as follows:

Let the same letters of reference be used.

Then the potential existing at the shunt terminals will be $E=rC$.

$$\frac{E-rC}{f}=\text{shunt current};$$

$$\frac{E-rC-e}{R}=\text{armature current};$$

$$\frac{E-rC}{f}+\frac{E-rC-e}{R}=C;$$

$$ER-rCR+fE-rfC-ef=CRf;$$

or,
$$CRf+rfC+rRC=fE-ef+ER.$$

Whence,
$$C=\frac{f(E-e)+ER}{fR+(f+R)r}.$$

Work done
$$=e\,\frac{E-rC-e}{R}.$$

But since C can be expressed in terms of e and constants, the work can be also expressed in terms of e and constants.

$$m\,\frac{E-rC}{f}=\text{shunt current},$$

$$nC=\text{series current},$$

$$m\,\frac{E-rC}{f}-nC=\text{effective current}.$$

$$=m\,\frac{E-r\,\dfrac{f(E-e)+ER}{fR+(f+R)r}}{f}-n\,\frac{f(E-e+ER}{fR+(f+R)r}.$$

But our conditions are such that

$$\frac{e}{e^1}=\frac{m\,\dfrac{E-r\,\dfrac{f(E-e)+ER}{fR+(f+R)r}}{f}-n\,\dfrac{f(E-e)+ER}{fR+(f+R)r}}{m\,\dfrac{E-r\,\dfrac{f(E-e^1)+ER}{fR+(f+R)r}}{f}-n\,\dfrac{f(E-e^1)+ER}{fR+(f+R)r}}$$

or $$\frac{e}{e^1}=\frac{mE[fR+(f+R)r]-mr[f(E-e)+ER]-}{mE[fR+(f+R)r]-mr[f(E-e^1)+ER]-}$$

$$\frac{nf[f(E-e)+ER]}{nf[f(E-e^1)+ER]},$$

or,
$$\begin{aligned}&mEefR+mEefr+mEerR-merfE+\\&merfe^1-merER-enf^2E+enf^2e^1-enfER=\\&mEe^1fr+mEe^1fr+mEe^1rR-me^1rfE+\\&me^1rfe-me^1rER-e^1nf^2E+e^1nf^2e-e^1nfER.\end{aligned}$$

Cancelling, we have

$$mfR(e-e)=nf^2(e-e^1)+nRf(e-e^1)$$

or, $$\frac{m}{n}=\frac{f+R}{R}.$$

That is, the number of turns in the shunt main field bears the same ratio to the number of turns in the series differential field, as the sum of the resistances of the shunt field and the armature bear to the resistance of the armature.

This is my method of winding for a machine of this character, and so wound, the machine will be self-regulating for any constant potential and for any load up to the maximum allowed, and even with a resistance in circuit and with varying potential.

The same peculiarity exists in those motors which has been pointed out in connection with the first class of differentially wound motors, and this will now be described.

The ratio of the magnetic moments of the shunt and series fields is

$$\frac{\dfrac{mE - mr\dfrac{f(E-e)+ER}{fR+(f+R)r}}{f}}{\dfrac{nf(E-e)+nER}{fR+(f+R)r}}$$

or,
$$\frac{mE[fR+(f+R)r]-mr[f(E-e)+ER]}{f[nf(E-e)+nER]}.$$

If $e=0$, this becomes

$$\frac{mEfR+mEfr+mERr-mrfE-mrER}{f^2nE+fnER}$$

or,
$$\frac{mR}{n(f+R)}.$$

But $\frac{m}{n}=\frac{f+R}{R}$.

Hence the ratio becomes $\frac{mn}{nm}=1$.

That is to say, if a motor of this character is at rest and the series coil in its normal governing position, and the circuit be closed to the motor, a zero field, or nearly so, will be produced; for under these circumstances the magnetic moments are equal, and either the motor will not start at all, or, if it does start, will run at a very great speed, take the maximum current at any given potential, and do little work or none at all.

This motor with constant speed, varying load, and *constant current* will now be considered.

Let the turns, resistance, etc., be designated as before. E is the variable potential at the terminals of the shunt field, and e the corresponding counter electromotive force.

We must eliminate E and express the work in terms of e and constants; e depends on speed and strength of field, but since speed is constant, e depends on the field alone.

$$\frac{E}{f}=\text{current in shunt field},$$

$$\frac{E-e}{R}=\text{current in armature},$$

$$K=\text{current in series field};$$

and therefore,
$$K=\frac{E}{f}+\frac{E-e}{R};$$

whence,
$$fRK = ER + (E - e)f,$$

or,
$$\frac{E}{f} = \frac{RK + e}{f + R}.$$

Our conditions are

$$\frac{e}{e^1} = \frac{\dfrac{mRK + me}{f + R} - nK}{\dfrac{mRK + me^1}{f + R} - nK}$$

or,
$$\frac{e}{e^1} = \frac{mRK + me - fnK - RnK}{mRK + me^1 - fnK - RnK};$$

or,
$$emRK + mee^1 - fnKe - RnKe = e^1mRK + mee^1 - fnKe^1\ RnKe^1$$

or,
$$(e - e^1)\,mRK = (e - e^1)\,fnK + (e - e^1)\,RnK$$

or,
$$\frac{m}{n} = \frac{f + R}{R}.$$

This is the same law of winding that holds when a machine of the same class is used for constant potential; and the same remarks in regard to the zero field apply as in the former case.

Also, as in the former case, the speed for any given current can be varied by varying the resistance and turns or the effective turns.

From the foregoing demonstrations it follows that a motor of either class depending for its regulation on this differential winding will regulate with a constant current only when working at less than fifty per cent armature efficiency; and that the same machine with the same winding will regulate on a constant potential circuit only when working at over fifty per cent armature efficiency.

The laws above set forth are for pure electro-dynamic motors; if there is any permanent magnetism, as in hard cast iron, or where permanent steel magnets are used, the law of winding is modified in so far as the residual or permanent magnetism is the equivalent of an electro-magnetic moment; but in this case, too, there should exist a zero field if the governing coil is normally closed when the motor is at rest.

It should be remarked here that in practice the quality of commercial iron makes some departure from theoretical laws necessary.

As an instance of the effect of reversing the governing coil in starting, if a constant potential motor has the series coil reversed when the full circuit is closed, there being margin enough on the field characteristic, we would have a field twice as strong as the strongest normal field, four times the strength when the motor is doing its maximum work per unit of time, and a momentary rotary effort eight times that existing when the maximum work is on. As soon as the speed comes up, if the governing coil is short circuited and then reversed, the motor will be self-regulating.

On some machines I take another step in overcoming, or rather counteracting, the distortion set up by the armature, by producing a distortion in the field magnets which is dependent on precisely the same current that flowed through the armature. I will describe one method only.

Main field-magnet coils are employed in shunt relation to the armature, differential field-magnet coils in series with the armature, and additional cumulative field-magnet coils, also in series with the armature. The main field-coils may be shunted upon the armature alone, or upon the armature and both the cumulative and differential series coils, or upon the armature or either of the series coils, the other series coil remaining outside the terminal of the main field shunt.

The object sought is to maintain the non-sparking points of the commutator cylinder constant by opposing the distortion of the magnetic field due to variations in the armature current by a counter distortion dependent upon such variations, whereby the magnetic resultant due to the armature and field magnet is unchanged, and the line of parallel cutting of the lines of force or point of least sparking is maintained in the same position.

In accomplishing the counter distortion of the field, the motor used is one in which the field-magnet cores extend in different directions from the field of force in which the armature revolves. The differential series coils are wound or arranged so that their greatest effect is produced on diagonally opposite parts of the magnetic field, and the cumulative series coils, so that their greatest effect is produced on the other diagonally opposite parts. The differential coils are arranged to have a greater magnetizing effect than the cumulative coils. A decrease of load, causing a decreased armature current, tends to shift the magnetic resultant of the armature and field magnet; but this also decreases the magnetizing effect of all the series coils, and, therefore, the parts of the field principally affected by the cumulative coils are weakened, and those principally affected by the differential coils are strengthened, whereby a distortion of field is produced opposed to that produced by the decrease of armature current, and hence the magnetic resultant—the line of parallel cutting and the points of least sparking—remains unchanged. Thus no shifting of the commutator brushes is ever required, except on account of wear.

I will now consider, from both the technical and commercial standpoints, the different classes of circuits on which motors may be used.

First. Arc light, or constant current circuits, in which the current supplied to the motor is kept constant at a certain number of ampères, ranging from six to nineteen ampères in different systems. The electromotive force at the terminals of the motor varies with the load.

Second. Constant potential, or incandescent light circuits, in which the difference of potential at the terminals of the machines is kept practically constant while the current varies with the load.

Third. Circuits in which the current and the potential both vary, as is the case where there is an appreciable drop or fall of potential on connecting lines somewhat removed from the source of power of a constant potential system, and in cases of special transmission.

I am now operating on all classes of these circuits, but since, because of the small ampère capacity of the current on arc light circuits, any large power must require a great difference of potential at the motor terminals, and variations of power will cause sudden and great changes of potential, the arc light circuits are useful in conjunction with arc lights for transmission of small powers only, or for constant work.

In considering the transmission of power from a general central station as an industry, that is, in a broad and comprehensive way, and not as an adjunct to some system of lighting, and leaving out of consideration for the present special cases of transmission, which forms a class of work by itself, practical and theoretical considerations make it imperative that the constant potential method of distribution is the only safe and feasible one.

It must be borne in mind that I do not agree with those writers who hold that central station distribution in limited areas is confined to "small domestic industries." We have then to deal with large and small powers, varying and constant loads, and the necessity of absolute independence both in operation and regulation of each motor. Furthermore, the motors may be designed for different classes of work, some constant in speed, others variable, and so on.

The only existing constant current circuits are used primarily for the operation of arc lights. At present, as I have said, these range in capacity from nineteen to six ampères. The unit of light which is required for general purposes necessitates an expenditure of about half a horse power of electrical energy. A greater expenditure would be extravagant. In order to keep the size of the conductors as small as possible, and to allow long extended circuits, the tendency is to reduce the ampères to the smallest number.

The conditions of an arc light probably will not allow this to go below about six ampères; the more ordinary unit is about nine and a half. The commercial conditions unquestionably will not permit in the future a much higher ampère capacity, because the size of the wire varies as the square of the current used. With a nine and a half ampère current, a motor to develop one horse power—supposing it to have an efficiency of eighty per cent—must have supplied to its terminals about 933 watts of electrical energy. In other words, there would be at the terminals of the machine an electromotive force of about 98 volts for each horse power developed. Suppose, now, we want to transmit one hundred horse power; it would then be necessary (if the motor be of the same efficiency) to supply to it 93,250 watts of electrical energy; and if it were on this 9½ ampère circuit we would have an electromotive force of over 9800 volts.

In practice, arc light circuits vary from, say, 1000 to 2500 volts. On a 1000 volt circuit about ten horse power could be recovered; on a 2500 volt circuit about twenty-five horse power. In other words, existing arc light machines, if devoted entirely to the transmission of power, are limited to the actual development, on even the largest machines in ordinary use, of twenty-five horse power; and if used in combination with light, there would be available on any particular circuit only a fraction of this. If we are going to deal with the transmission of the tenth of a horse power, or one-half, or even two or three horse power, and are willing to have the element of danger as well enter into these small transmissions, then we can work with an arc light circuit; but if we are going to transmit units of five, ten, fifteen, twenty, or twenty-five horse power, we cannot deal with the arc light circuit; it is utterly impossible.

In Boston we have recently put upon certain lines nearly two hundred horse power. Suppose this were supplied on 9½ ampère circuits. No less than eight circuits of 2500 volts each would be required, and probably more, because with units as high as fifteen horse power and this division of circuits, the law of general average could come into play in but a very limited manner.

These eight 2500-volt circuits represent the capacity of a 460 arc lamp station, and to deliver the power not a single lamp could be used at the same time. The constant current method of distributing power is the limited and unnatural method; the constant potential, the comprehensive and natural method. This is a fact entirely independent of the question of relative electrical potentials, because on the constant potential circuit we can work at 100, 1000, or 5000 volts, if we please. In short, electrical distribution follows much the same laws that hold in gas, water, and steam distribution.

We may now with profit consider some of the peculiarities which distinguish special cases of power transmission, some of the methods which may be used, and also certain economic problems which are of prime importance. We will first note the behavior of a series-wound motor having a constant torque or load per turn. The motor being at rest, as the e. m. f. of the generator is raised the current $\frac{E}{K}$ increases until the torque is great enough to start the motor against its load. A motor e. m. f. is now created, and the current becomes $\frac{E' - e}{K}$. As the e. m. f. of the generator E' is increased, this current $\frac{E' - e}{K}$ *remains perfectly constant* and equal in value to $\frac{E}{K}$, and the motor increases its speed in the ratio $\frac{E' - E}{E}$.

In considering special cases of transmission, that is, between a single generator and motor, the better method is to use a circuit of variable current and electromotive force, and here, too, plain series machines may be used. These, however, must be definitely related, and I will very briefly touch upon the theory of this method of transmission.

We have the condition that the same current passes through each field and armature. We also have the condition that the speed is constant but that the work is variable. Work may be expressed as the product of speed and torque, and since the speed is constant, it follows that the motor torque must vary directly as the work.

Again, the work may be expressed by the product of the motor e. m. f. e and the current C. Since the speed of the motor is constant, e must vary directly as the strength of the field, which, if of low saturation, will vary directly as the current, and if highly magnetized, will vary in a less degree.

If E is the e. m. f. of the generator, and K the resistance of the circuit,

$$C = \frac{E - e}{K},$$

and, as above expressed, we have

$$E \propto e \propto E - e \propto C,$$

and

$$\text{Work} \propto eC \propto C^2 \propto e^2 \propto E^2.$$

The dynamo being driven at a constant speed, E varies as the strength of its field.

If $m =$ the number of turns of wire in the dynamo field and n those in the motor field, then the ampère-turns, or magnetizing forces, are mC and nC.

It follows from what precedes that mC should vary with nC in the same proportion. In other words, *the characteristics of the generator and motor must be similar in character between the limits of variation of load.*

The efficiency of the circuit being $\frac{e}{E}$, we have the following law, *that the efficiency is a constant for all loads in the limit of automatic regulation.*

If the machines are of the same general type, then, when correctly proportional, *the ratio of their size should be the same as the efficiency of the circuit.*

It is as well to give here certain general laws concerning the transmission of energy on a complete metallic circuit without leakage, which may be expressed as follows:

First, with any given work done by a motor, loss of power on the lines, electromotive force at the terminals of the motor, and distribution, the weight of copper varies as the square of the distance. That is, if the distance is doubled with these given conditions, four times the weight of copper will be required.

Second, with the same conditions, the weight will vary inversely as the square of the electromotive force used at the motor. That is, if using double the electromotive force at the motor, it is necessary to use only one-quarter of the weight of wire.

Another way of expressing this is, that if the weight of copper is fixed, then, with any given amount of power transmitted and a given loss in distribution, the distance over which the power can be transmitted can be increased in directly the same ratio as is the electromotive force; for example, if a thousand pounds of copper is required to transmit a given amount of power with a given loss, and it is desired to double the distance with the same weight of copper, then the electromotive force must be doubled.

Again, with the same cross section of conductor, the distance over which a given amount of power can be transmitted will vary as the square of the electromotive force.

These laws may be expressed in a formula which is of frequent utility in determining the condition on ordinary circuits, and has also a widespread application in special work.

Let $l =$ distance between the generating and receiving stations in feet, plus the sag.

$n =$ number of effective horse power to be delivered on the motor shaft.

$E =$ electromotive force at the terminals of the motor.

$v =$ number of volts fall of potential on the line,

$E + v$ being, of course, the electromotive force at the beginning of the line.

$K =$ efficiency of the motor.

$CM =$ circular mils of conductor.

An electrical horse power is 746 watts, watts being the product of current by electromotive force. Then for any horse power, a motor efficiency of a, and an e. m. f. of E at the motor terminals, we have the number of ampères equal to $\frac{746\,n}{Ea}$.

Allowing 10.5 ohms as the resistance per mil-foot of copper, the total resistance would be $\frac{21\,l}{CM}$.

From the above we have

$$v = \frac{746\,n}{Ea} \times \frac{21\,l}{CM}$$

or

$$CM = \frac{15{,}666\,nl}{Eva}.$$

Let me give you a practical illustration. Suppose we have a motor the efficiency of which is ninety per cent at 400 volts electromotive force and when developing ten horse power, and that we wish to transmit this ten horse power 5000 feet from a station, and elect to lose about nine per cent on the line.

Our initial electromotive force will be 440 volts, and we would have

$$CM = \frac{15{,}666 \times 10 \times 5000}{400 \times 40 \times .90}; \text{ or}$$

$$CM = 54{,}396, \text{ which is about equal to a No. 4 B. W. G.}$$

Again, suppose we wish to transmit five horse power over a distance of one mile on a complete metallic circuit of 45,000 CM, allowing five per cent increase of length for sag, and no leakage. Suppose, further, that the initial line potential be 300 volts, and that we wish to have 250 volts at the motor terminals, it is required to find the commercial efficiency which the motor must have.

Transposing our formula we have

$$a = \frac{15{,}666\, nl}{Ev\, CM},$$

and substituting,

$$a = \frac{15{,}666 \times 5 \times 5544}{250 \times 50 \times 45{,}000} = 76 \text{ per cent.}$$

This formula is useful in determining what we cannot do, as well as what we can do. For example, if we made the condition ten horse power, all others remaining the same, the commercial efficiency of the motor would have come out 152 per cent, a most excellent machine indeed, and yet it is precisely this absurd thing that people practically say they will do in many of the statements which are made in relation to this subject. No science admits of more easy determination of conditions by plain and simple laws, and none brooks less violation of them.

In considering the transmission of power, a very curious fact may be demonstrated by a formula for determining the minimum cost of plant, where the amount of power at the generating station is practically not limited, and where there is no line loss from leakage, the line loss being measured simply by the fall in potential.

The cost of a plant of this character can be divided into four parts, that of the motors, the line erected, the dynamos, and the power plant, whether water or steam. I will assume that the cost of the dynamos and motors cost the same amount per horse power or other unit, no matter what the electromotive force used. While this is not strictly true, for all practical purposes, with large units, and speaking from the commercial standpoint, it is so. This being the case, for any given power the cost of the motor is a constant independently of the potential used. The greater the loss on the line, the less the cost of the conductors, but the greater the cost of the generators. On the other hand, the less the loss on the line, the greater its cost, but the less the cost of the generating plant. It follows then that the least cost to the contractor is determined when the increment of saving in the cost of the generator is equal to the increment in the cost of the line.

We have for the size of the wire necessary to transmit energy on a complete metallic circuit without leakage, the formula already given,

$$CM = \frac{15{,}666\,nl}{Eva}.$$

If d equals the weight of one mil-foot of copper, then the weight per foot of our conductor would be

$$\frac{15{,}666\,nld}{Eva};$$

and the total weight for length $2l$—this l being of course the actual distance plus the sag of the wire—would be

$$\frac{31{,}332\,nl^2d}{Eva}.$$

If b is the cost in cents per lb. of copper in line erected, we have for the cost of the line, which will of course depend upon local conditions,

$$\frac{31{,}332\,nl^2db}{Eva}. \tag{1}$$

Let E be the e. m. f. at the terminals of the motor; v the fall of potential; β the commercial efficiency; E' the e. m. f. of the generator, and n the number of horse power developed by the motor.

Then $\frac{E'}{e}$ = ratio of the watt capacity of the generator and motor, $\frac{n}{a}$ = energy delivered to the motor terminals, $\frac{(E+v)\,n}{E\,a}$ = energy delivered to the line, and $\frac{(E+v)\,n}{Ea\beta}$ = the horse power delivered to the generator.

If K = cost in cents of the generators per horse power required to drive them, and L the cost per horse power of the steam or water plant, then the cost of the generating plant complete would be

$$\frac{E+v}{Ea\beta}\,n\,(K+L);$$

and the cost of the total plant when M is the cost of motor per horse power developed,

$$TC = \frac{31{,}332\,nl^2db}{Eva} + \frac{(E+v)(K+L)\,n}{\alpha\beta E} + nM, \qquad (2)$$

which, differentiated for a minimum with v as the variable, gives as a condition

$$\frac{31{,}332\,l^2db}{v^2} = \frac{K+L}{\beta},$$

whence,

$$v = l\sqrt{\frac{31{,}332\,db\beta}{K+L}},$$

or, substituting for d its value .00000302705,

$$v = .308l\sqrt{\frac{b\beta}{K+L}}.$$

In other words, *with fixed conditions of cost and efficiency of apparatus, the number of volts fall to get the minimum cost of the plant is a function of the distance alone, and is independent of the total electromotive force.*

The value of this will at once become apparent. Suppose at some place where we wish to transmit a large amount of power over a considerable distance, the cost of the water plant, that is, of the turbines, sluice-gates, water-channel, building and shafting, should cost $50 per horse power; that of the generator $35 per horse power; copper, per pound, erected, 20 cents; and further, suppose our dynamos to have an efficiency of 90 per cent. Our formula then becomes

$$v = \frac{l}{70}.$$

If the distance be five miles, the number of volts fall in potential would be

$$v = \frac{5 \times 5280}{70} = 377 \text{ volts.}$$

If 500 volts be used at the motor, the e. m. f. at the generator terminals would be 877 volts; and if 1000 volts at the motor, then 1377 at the generator.

While this fall of potential is independent of the total electromotive force, this last of course determines in part the total cost.

A consideration of the above formula and the investment and cost per horse power in any particular locality will quickly determine the practicability of transmitting power by electricity rather than generation by a local steam plant.

The commercial efficiency of the circuit may be expressed by the equation

$$\frac{E\alpha\beta}{E+v}.$$

It follows that, *to maintain the same commercial efficiency and the minimum net cost of plant, the e. m. f. at the terminals of the motor and the generator must be increased in precisely the same ratio as is the distance.*

Let us look at the problem in another light.

Suppose with the costs of material as above given we want to get a net commercial efficiency of sixty per cent on a ten mile circuit, with dynamos and motors whose *couple efficiency*, $a\beta$, if I may use the term, is 80 per cent.

Substituting in our formulas the values given, we have as conditions

$$\frac{E}{E+v} \times \frac{4}{5} = \frac{3}{5},$$

or,

$$\frac{E}{E+v} = \frac{3}{4} \text{ or } E = 3v,$$

and

$$v = \frac{l}{70} = \frac{10 \times 5280}{70} = 754,$$

whence,

$$E = 2262 \text{ volts},$$

and

$$E + v = 3016 \text{ volts}.$$

Under like conditions, if the distance is only five miles,

$$E_1 = 1131,$$
$$E_1 + v_1 = 1508, \text{ and so on.}$$

We can easily make a general formula. Let $\lambda =$ the commercial efficiency required. Then we have

$$\frac{Ea\beta}{E+v} = \lambda,$$

or,

$$v = \frac{a\beta - \lambda}{\lambda} E.$$

Also,

$$v = .308\, l \sqrt{\frac{b\beta}{K+L}},$$

whence,

$$E = \frac{.308\, l\lambda}{a\beta - \lambda} \sqrt{\frac{b\beta}{K+L}},$$

which gives the e. m. f. at the motor terminals, and from this all other elements can be deduced.

From these formulae we see that, with fixed conditions not only is the number of volts fall of potential dependent on the distance alone, *but with any fixed commercial efficiency the e. m. f. at the* *motor and generator terminals is also dependent simply on the distance.*

Again, *the number of volts fall and the motor e. m. f. vary inversely as the square root of the cost of the generating plant.*

Another fact is important. Since the circular mils vary inversely as *Ev, the size, weight, and cost of the wire vary directly as the cost of the generating plant.*

One of the most important applications of the principle of reversibility which I pointed out as characterizing dynamos and motors is its possible use in braking trains. The electromotive force depends upon the strength of the field and the velocity of the armature, and is independent of everything else. It is evident, therefore, that if the strength of the field magnet is increased, the motor electromotive force is also increased; and if the increase of field strength is continued, the initial and counter electromotive forces will become equal, and then the counter or motor electromotive force will predominate. The propelling motor will now become a generator and give current to the line, and its mechanical effects are reversed, so that it brakes the train instead of propelling it, and the current generated by it and the braking power or reversed mechanical effect are now controllable by further increasing or by rediminishing the strength of field.

It will be seen that mechanical energy is received by the reversed motor according to the mass of the train and its velocity. If a train should start on a down grade unprovided with a brake, the energy of falling would tend to increase its speed; but when this method of braking is used, this mechanical energy is transformed in the machine into electrical energy delivered to the line, and augmenting that supplied from the generating stations to the other trains, which may be moving upon up-grades or on levels.

When it is desired to slow down a train on a level grade, the field is increased, as before, until the counter electromotive force predominates over the initial, and the energy stored up in the moving train is exerted to run the machine as a braking dynamo. As the train slows, however, the diminution of speed of the armature will tend to diminish the counter electromotive force, and the increase of field strength must therefore be continued, so as to still maintain the counter electromotive force above the initial and keep the machine running as a generator as long as practicable, when other methods of braking, as, for example, closing the armature circuit on a local regulating resistance or brake circuit, may be used.

I will give an instance to show how effectively this method may be employed, premising that when large masses of iron are used in the field magnets, the strength of the field can be varied within effective limits two or three hundred per cent, and also that a well constructed armature can carry for a short time fifty, seventy-five, or perhaps even one hundred per cent more current than it can stand for any long run. Suppose the armature of a motor to have a resistance of three-tenths of an ohm, with field coils in shunt relation, and provided with suitable means for varying their strength. Suppose the initial electromotive force to be five hundred volts, and forty horse power to be required from the motor when running at its maximum. Allowing for losses in conversion, this forty horse power would be about thirty-two thousand watts. The counter electromotive force would be four hundred and eighty volts, the effective electromotive force twenty volts, and the current sixty-seven ampères. The electrical efficiency of the armature would be ninety-six per cent. Suppose the strength of the field to be increased about four per cent, the speed remaining the same, the motor running on a down grade; the counter electromotive will be increased to five hundred volts, and the motor armature will then be perfectly passive electrically, neither taking from nor giving to the line. Let the field strength be increased again one per cent, and let the increase be continued in the same ratio. The result is shown in the following table:

Total field increase.	Current to line.	Approximate energy required from train, allowing for losses.
5 per cent.	13.3 ampères.	9.5 horse power.
6	29.3	20.9
7	45.3	32.7
8	61.3	44.7
9	77.3	56.9
10	93.3	69.3

From the above it will be seen that by simply increasing the field strength one twenty-fifth part, the machine is converted from a motor driving a train with forty horse power of effective work, to a perfectly passive machine, allowing the train to run absolutely free. Then by increasing the field one one-hundredth part the motor at once exerts a positive braking force, and on an increase of about eight and one-half per cent above its original strength it will give back to the line current equal to that which was originally taken from it, sufficient, evidently, to run some other motor of the system which may at that time require that amount of current; and by increasing the original field ten per cent the machine acts as a dynamo, requiring more than fifty per cent more energy than is demanded to run it as a motor developing forty horse power.

This method of braking, it will be seen, is under perfect control, and it is the most economical system possible for an electric railway, since whenever a train descends a grade, and whenever a train stops, the energy stored up in the moving train is delivered in the form of electrical energy upon the line.

Consider for a moment what occurs on a steam railway train making frequent stops at short intervals. Suppose it to be ascending a grade, then the engine exerts more than its average amount of power. When it reaches the top and enters upon a down grade, steam is shut off, and when the train begins to run faster than is desired, the brakes are put on, and the energy of the train is then converted into heat on the rims of the wheels and on the brake-shoes. In other words, all the energy in excess of that necessary to run the train on a level which has been required to climb the grade is now thrown away in going down the grade, instead of being utilized, as in this system; and, furthermore, additional steam is actually required to check the tendency to augmented speed. Then when the train approaches a stopping place, or whenever it is necessary to slow the train down quickly, steam has to be employed to actuate the brakes, and all this additional power is simply thrown away. By the electrical method of working, the greater part of this loss may be entirely obviated.

It is true that not all of the energy will be converted into electricity, but a large proportion of it will be.

On a double-track road, with both tracks supplied from the same main circuit, the energy given to one track is also communicated to the other. The up-grades on one track being always balanced by the down-grades on the other track, it is evident that the total up-grade of the whole system is equal to the total down-grade thereof. Therefore, energy being expended on the up-grades, and given out to nearly the same extent on the down-grades, the energy required in the system is that sufficient to move a train upon a level with a slight percentage added; but on a steam railway the energy required is not only that sufficient to run a train on a level, but, in addition, that necessary to raise it from the lower to the higher grades on both tracks, no matter how many of such grades there may be.

Suppose the Third Avenue " L " road of New York were equipped with electric motors, let us consider what the application of this method of braking would mean. There were not long ago, at about six o'clock in the evening, sixty-three trains in operation at one time on about eight miles of double track. The maximum capacity of the engines is about one hundred and eighty horse power, giving an aggregate of 11,340 horses. The work, however, is continually varying, because the trains have to make stations about one-third of a mile apart in eighty seconds, and the average work done is only about seventy-one horses, or 4473 horses total.

Yet the wasteful character of the expenditure is shown by the fact that fifty-nine per cent is expended in overcoming the inertia of the train in getting underway, twenty-four per cent in lifting it on grades, and seventeen per cent only in traction. If the 4473 horse power which represents the average were supplied by electricity in the ordinarily proposed methods, with a recovery of say sixty per cent, then there would be required not less than 7455 horse power at the central stations. By using the system of braking I have described on down grades and in stopping, enough of the energy of the train can be reconverted into electricity to entirely make up all the losses of conversion, transmission and reconversion, so that at the central station only about 4473 horse power would be required, a saving in investment, and coal consumption of $7455 - 4473 = 2982$ horse power.

Instead of the current being all supplied by the main generating station at one or more points, it would be supplied from nearly as many additional moving stations distributed along the whole line, as there are trains slowing down or running on down grades. With any given size of conductor, the loss would be much less, and, with the same losses, the sizes of conductors could be very much reduced.

I have thus shown how, in the application of motors to both stationary and railroad work, the control of the motor electromotive force is the key to the control of the power and speed. I will give one or two more illustrations of the practical character of this theory and how it may be utilized. In our factory one of the methods that we have of testing motors is the following. The power which we have is limited. We sometimes wish to test a number of motors together, and in doing so to develop an amount of power which it is impossible for us to spare from our shafting. Suppose, for example, that we wish to test two 20 horse power and two 7½ horse power motors, an aggregate of about 55 horse power. One of these 7½ horse power motors is driven as a dynamo. This is electrically connected to the second one, which is driven from the first as a motor. Overhead, we have a line of countershafting, on which are three pulleys. Our two 20 horse power machines are belted up to these pulleys, and likewise the 7½ horse power motor. The like terminals of the large motors are then connected together, and an ampère meter put into one branch of the circuit. One terminal of each field is likewise connected to its proper line, and the other terminals of these fields are brought to the movable levers of a three-part circuit changing switch. One contact is carried to the other line, and between it and the other two is inserted a variable resistance, which, in the middle position of the switch, is short circuited. We have, then, the two large motors connected in an *electro-mechanical couple*, and to the same mechanical shafting is connected a third motor. The dynamo being started, the switch set in the middle position, the motor is speeded up, which sets the countershafting in operation, and drives both the 20 horse power motors as dynamos, each exciting its own field. If the machines are symmetrical, no current whatsoever will pass over the branch connecting the two; they are simply in the position of two dynamos in parallel circuit with each other, with no external circuit and no path over which the current can flow, except that through their field magnets; consequently, very little power, save that of friction, is taken. The switch being moved in one direction, the resistance is thrown into the field of one machine. The electromotive force which it develops at this particular speed is now reduced; it becomes a motor, and current will flow over the connecting mains from the other machine, which is now a dynamo, which current is expressed by the quotient of the difference of the electromotive force of the two machines by the resistance of the two armatures and the connecting mains. By varying this resistance, this current can be made of any value up to the limit. We have here, then, one machine acting as a motor, and driving on to the countershafting with a certain number of horse power, this countershafting driving the other machine as a dynamo with a certain greater amount of horse power, this second machine furnishing the current which operates the first as a motor. The deficit, or loss of efficiency between the two machines, is made up by the third 7½ horse power motor; in other words, one machine is driving the other electrically as a motor, and the motor through the countershafting is driving the first one mechanically as a dynamo, the deficiency being made up as I have just said. By reversing the switch, the resistance is first cut out of the field, and then thrown into the field of the opposite machine. This machine now becomes a motor, and the other machine becomes a dynamo. This reversal is not instantaneous, because it takes time for the field magnets to charge and discharge. The ampère meter will drop to zero, and will then rise again progressively.

This method of testing can be used for two purposes, one for testing the actual horse power developed and the *couple efficiency*, which can be done by measuring the current, the electromotive force between the machines and the horse power delivered to the shafting by the third motor, and for the other purpose of testing simply the heating capacity of the armature coils with a given number of ampères. For this latter purpose it does not matter practically whether the machines are run at their normal speed and generate their normal electromotive force, or whether some lower electromotive force is used. If a lower electromotive force is present, it simply means that there must be a greater ratio of difference between the field magnet strengths and a larger resistance used with the reversing switch.

This method of testing, where there can be an instantaneous and controllable reversibility of the dynamo and motor by the mere touch of the finger, is probably one of the most beautiful, as it is one of the most useful, applications of this characteristic of machines. By it we can test motors of a capacity of, say, fifty-five horse power, with a belt expenditure of about eight or ten horse power.

A similar method of testing can be used in testing the dynamos employed on alternating circuits. It is now customary in testing large machines, say one thousand lights capacity, to use banks of lamps or artificial resistances to test their capacities. Mr. Hopkinson pointed out, some five or six years ago, that two alternating-current machines could be operated in multiple circuit, but could not be operated in series, and one of the practical things which have been developed is this: that if two alternating machines are run in multiple circuit, before they can be thrown together in safety that they have to be brought into unison. It must be remembered that in an alternating-current machine the variation of electromotive force instead of being two or three, or four or five per cent, as with a constant-current machine, is of the greatest degree. With a one thousand-volt machine, the electromotive force is first as one thousand volts positive and then one thousand volts negative, and this may occur a hundred times a second. If two machines which are not in unison are thrown together on the same circuit, one is retarded and the other is accelerated, the one acting as a dynamo and the other as a motor, and in the twinkling of an eye they are brought into unison with a report and a shock so sharp that it has for the uninitiated a startling effect, and is, of course, a very severe wrench upon the machines. It is common to excite the field magnets of alternating-current machines by separate exciters. If they run at the same speed, have the same characteristics and have field magnets of the same strength, then when they are in unison both machines will act as dynamos, and neither will take or give current to or from the other. If they are out of unison, then because of the rapidity of the pulsations of these phases and the great change of electromotive forces in the machines they will necessarily come together. One cannot be run as a motor and the other as a dynamo practically by maintaining them out of unison.

Let the two machines be, however, started together with zero fields, and when running at their normal speed let the field magnets be gradually strengthened. The machines will come to unison without trouble. If now, when thus running in unison, the exciting circuit be arranged, as is very easy, so that the field magnets of either can be weakened, then the phase curve of one may be made lower than that of the other by any required degree. The pulsations will be the same in number, they will change in character at the same instant and in the same way, but since there is a difference of electromotive force, the one developing, say, five per cent more than the other, then one will be running as a motor and the other as a dynamo. Both can be driven off the same line of countershafting or engine, and two one thousand-light machines can be tested to their full current-carrying capacity with a very small fractional part of the power which they each separately require, and their dynamo and motor phases can be reversed with the same rapidity and with the same ease and safety as I have described with the constant current machines.

You have been kind enough to express a wish to hear something of the commercial development that has taken place, and I will give you briefly some facts showing how entirely beyond the visionary realm the transmission of power has gone. Some three years ago, the first electric motors which I put into practical use in territory outside of my own jurisdiction were sent to Lawrence, Massachusetts, and one of these was used in an isolated plant for operating a cotton elevator in the Pemberton Mills. Since that time the work has gone forward steadily, at first slowly, and of late with a rapidity which has exceeded my most sanguine expectations.

The first companies on whose circuits what are called the constant speed motors were first introduced were the circuits of the Edison Electric Illuminating Companies, and now a very large number of these companies, as well as many others, are coming to realize that one of the most important matters to which they can give their attention is the development of the use of motors for all industrial purposes within the range of the territory covered by their conductors. The result has been that these machines are now being introduced in the United States in the cities of New York, Chicago, Boston, Des Moines, Elgin, Oskaloosa, Pittsburgh, Chester, Williamsport, Lancaster, Shamokin, York, Detroit, Topeka, Hutchinson, New Orleans, Cleveland, Cincinnati, Springfield, New Brunswick, Fall River, New Bedford, Milford, Taunton, Lawrence, Woonsocket, Fort Meyer, Waterbury, Annapolis, St. Louis, Abilene, Pawtucket, Syracuse, and also into Canada, the Argentine Republic, Austria, Germany, Italy, and Japan, and they are being applied to every possible use. In Boston there have been introduced within the past few months nearly sixty of these machines on one circuit, varying from one-half to fifteen horse power in capacity. In New York there are about sixty machines in operation, and the number is now rapidly increasing.

The position I early took in this matter was briefly this: that electricity could fill the field in a far more complete and satisfactory manner than, but in very much the same general way, as the distribution of power from a central station by means of gas, steam, water, or compressed air. The use of any of these elements involves engineering problems. To be successfully solved, not merely as a scientific fact, but in a commercial sense, every part of such system should be in thorough accord with every other part. It is not sufficient that there should be a good dynamo, or a good system of distribution, or a good motor, but that they should be definitely related, the units, the distribution, the area of the distribution, the sizes of the conductors, and the electromotive forces being determined with reference to each other, and to the ultimate demands to be made upon the central station. Nor could any elements of such a system be in doubt. It goes almost without saying that large engines can be operated and large powers developed under as little general supervision as smaller ones, and under far less supervision than several units of small powers. The cost of the generation of power is much less in large engines, both in the amount of coal and water used and the matter of attendance, and also in the general expense. It follows, then, that if the power of a manufacturing district can be centralized, it can be developed at a much higher efficiency and at a very much lower cost than where it is being generated in a large number of units. If, after such centralization, it can be distributed to a large number of users in the district with only a moderate loss, then supposing only that the same amount of power is sold as is generated in the central station, this plan of generating power would still have the advantage, in point of economy; but when we take into account, as shown by our records, and as is being borne out by practical experience every day, that under the circumstances a central station can take advantage of a low average percentage in use of the capacity of machines, it then becomes apparent that if the system is properly constructed and operated there is not only not a loss, but a great gain in the centralization of steam power; and this will hold true whether dealing with a central station of one hundred or ten thousand horse power, and, if operating under proper electromotive forces, whether the district is a square mile or ten square miles. In fact, electricity is the most convenient, tractable, yet powerful means of carrying and distributing energy or motion from one point to another. As a means of transmission, it has greater advantage over steam, water, gas, or compressed air, in that the system of conductors is far more flexible in its arrangements, and capable of much greater ramifications than any of its competitors. It can be operated under much higher relative pressures or potentials than the other methods of conducting power, and hence it can be distributed with very much smaller conductors and much smaller investments and losses. Of course the truth of this depends upon the efficiency of the different parts of the system.

There are three ways in which power is lost after it is generated in a steam engine and delivered to the dynamo pulleys. The first is in the dynamo. This has now been brought to such a high state of efficiency that there are several good types of machines which have a commercial efficiency as high as ninety per cent. The second loss is that which occurs in the distributing wires or conductors, and this depends upon the electromotive force used, the distance over which the current is distributed, the distribution and arrangement of the conductors, and the amount of current carried. This loss should not exceed in a general district over ten per cent. The third loss is in the motors, where the energy of the electricity is reconverted into mechanical power. Motors vary in their efficiency. To truly answer the commercial conditions, the current used should be almost directly proportional to the work done. The higher the efficiency of the motor, the more nearly will this law hold. Small machines are not as efficient as large ones, nor is every motor of equal efficiency under all loads; but in large machines the efficiency under full loads is now about ninety-one per cent.

As between two motors of differing efficiency, with that of the lesser efficiency not only would the size of the conductors which would be needed in a particular area to distribute a given amount of mechanical work be much increased, and the area over which any given amount of power could be distributed with a given weight of conductor be very much smaller, but also the capacity of both the dynamos and engines in a central station would have to be very materially increased to get a given output of mechanical work. Increased area, lessened weight of copper, greater recovery of power, and a larger amount of mechanical output, as well as a greater excess capacity of motors, and a less proportional investment in central station appliances and equipments—all these are in favor of the motor having the highest efficiency. The effect upon the lights where they are supplied from the same circuit is also very much less marked with motors of higher than with motors of lower efficiency. In transmitting power over long distances, even in single units, any increase whatsoever in the efficency of the motor or dynamo becomes exceedingly important, because the investments in conductors are very large.

Theoretical conclusions, however, were not of sufficient weight, nor were they generally understood, and one of the greatest difficulties we met with in the introduction of motors was that of determining a method of charging for power, because, on account of the lack of knowledge of the character of the machines and the variable work which they have to do, a contract basis seemed at first inadvisable, and the ordinary current rates for lamps seemed exorbitantly high. Few managers could rid themselves of the notion that, because there was a loss, first in the dynamo, then in the conductors, and finally again in the motors, covering an aggregate of about thirty-five per cent, that it would be impossible to compete with steam when supplied directly. In order to determine these facts, and to prove to people who were selling power, not only that there was not a loss, but actually an apparent gain in the transmission from a central station; that motors were not to be treated as toys, but as important factors in the industrial arts, and that they would be justified in making a charge for electric power service based upon the sensible method of a contract—records were obtained and calculations made something after the following manner: After several motors had been put into use, we sent out a blank circular requesting, among other things, the number of hours' use which the motors averaged every day, the class of duty, and also the monthly payments, then mostly made on a meter basis. The reports were varied. Some of the records extended over considerable periods of time, and they established the fact that motors, as a rule, do not average over thirty-three per cent of their capacity for the ten hours of a working day. This, in fact, is a large average. This may to a great extent be understood from the following statements: A motor is absolutely automatic. The total current used in machines of high efficiency is almost directly proportional to the work done at any instant. The result is that if the work slacks for a moment, so also does the current, and in nearly the same ratio. Almost all work is spasmodic in character. Motors have to be put in for their maximum capacity, but not one class of work out of a hundred offers continuous duty. Some motors are stopped, and in others which are running the work is constantly varying from the maximum to the minimum. An illustration of this may be cited in the case of elevators. If twenty elevators, each requiring a maximum of five horse power, were driven from the same line of countershafting, they would not require an engine of over forty horse power, because some would be going up, some going down, others standing still, and in not two cases out of the twenty would simultaneous trips be made, while in not one trip in five hundred would an elevator be hoisting its maximum load from the basement to the loft. Comparison also may be made with existing incandescent light plants. Practical experience shows that not over fifty-five or sixty per cent of the total number of lights connected on a station are used at any one time, although it is possible to use them all. But incandescent lamps when they are in use take their full amount of current. Not so with motors. A certain percentage of the motors, just as with the lights, would not be in use at all, and in most of those in use the current would be continually varying, just as if the lights of an incandescent light station were being turned up and down from one to sixteen candle power, as well as many of them being turned out. The recovery in an ordinary district with eighty-eight to ninety per cent of the power delivered to the dynamo pulleys converted into electricity on the line, and ten per cent loss in distribution, is about sixty-five per cent. This sixty-five per cent, however, where the work is distributed, is only thirty-three per cent of the capacity of the motors for which power can be contracted. In other words, for every one hundred horse power in a central station, sixty-five horse power at any one instant can be delivered under an ordinary distribution, and this sixty-five per cent is only one-third of the power which can be contracted for, provided there are a large number of motors in use. Of course, where only one motor can be used, then sixty-five horse power only would be obtained, but the object of a central station is to take advantage of the intermittent character of the work, and that it can be done is shown by the records which we have of a large number of motors in use.

The future, then, of motors in connection with central stations is assured, but the application of motors to stationary work, or more properly in combination with centres of supply such as the ordinary stations for electric lighting and power, is but one field, although a large one. There are many special fields of work, each of which demands large capital, and offers a wide range of application. Among these may be mentioned the application of the transmission of power to mining works. At present, in single plants, both in the mining of the common and of the precious metals, immense sums are invested in elaborate systems for the transmission of power by compressed air, single plants sometimes costing as much as a half a million dollars. Such a system of transmission must necessarily be costly. Not one case exists in which electricity could not be better used and with a very much reduced investment.

The transmission of power in single units for a variety of purposes too numerous to mention, such as, for instance, the operation of the transfer tables of the C., B., and Q. Railroad at Aurora, and the operation of overhead cranes, is itself a field requiring a great deal of thought. Some idea of the progress made may be gathered from the fact that we have now about twenty-five or thirty different types and classes of machines, and I know that the near future will require fifty or seventy-five.

Again, the substitution of motors for horses in street car work, using in some cases the conduit, in others the overhead wire, and others the storage battery, is now rapidly coming into favor. On the two latter classes of work we are now actively engaged, and are just at present much interested in the most extensive electric railway system which has ever been contracted for, that of Richmond, which comprises forty cars and eleven miles of track. The great margin between steam and horse power gives ample room for increased efficiency and lessened cost of operation, especially where a number of cars are in operation, because here, as in regular central station work, the apparent output of power will be greater than the actual power of the central station, and, unlike horses, the motors do not require to be fed for twenty-four hours in the day independent of whether they are being used or not.

In one sense, that of size, the most important immediate experiment in which I am engaged is the development of motors for application to the movement of heavy trains on the elevated railroad. I was engaged last year for a considerable period in carrying on experiments on one of the branches of the elevated railroad, during the progress of which one of the standard elevated railroad cars, on a heavy grade and with a current of about six hundred volts potential, was handled under all speeds up to twenty-one miles an hour entirely by the motors, and without the use of hand-brakes, the practice of the recovery of the energy of the car, of which I have already spoken, being there very thoroughly developed. We have now stopped this experiment and have under way the largest apparatus of the kind ever undertaken. This consists of a motor car of special construction, which is designed partially for passengers, and is intended to haul itself and five or six other cars; in other words, a hundred and forty ton train, and this at speeds as high as twenty-eight miles an hour. The middle portion of this car is to be used for passengers, but each end is reserved for the engineer and for duplicate controlling apparatus. Under each end of the car is a heavy iron truck fitted with two pairs of forty-two inch Krupp wheels and five-inch Midvale steel axles. On each axle is to be placed a duplex motor, the normal capacity of which is seventy-five horse power, but which can be worked up to a capacity considerably higher than this. Each motor is centered on the driving axle and drives from each end of the armature. Each motor weighs four tons. The armatures, of which there will be eight altogether, are about eighteen inches long and seventeen inches in diameter. Each of the eight field magnets with its wire will weigh at least a ton. The total weight of the car with passengers will be about thirty-two tons, but it is distributed over the entire distance between two columns. With a tangential strain on each armature of only about twelve hundred pounds, there will be a draw-bar strain of nearly 13,000 pounds; and this is not by any means the full capacity of the motors. The total power of the motors on this car will be double that of the heaviest locomotive on the road, and the traction coefficient more than twice as much. It will be some months before this is ready, because the work is being elaborated in great detail.

One of the most important applications to which I may call the attention of the gentlemen present is that of the use of electric motors on board ship. The uses to which motors can be applied on a man-of-war are numerous. It will probably be argued by many, when the proposals are made to carry on certain operations by means of electricity, that there is some doubt as to their practicability in so complex an organization and one subject to so many peculiar conditions not met with elsewhere as is a man-of-war. Similar objections were made a few years ago when it was suggested that the incandescent electric light ought to be introduced in the place of the then existing system of lighting. In 1881 I made some efforts to introduce the incandescent electric light on board our ships, and afterwards in 1882 I attended an exhibition at the Crystal Palace, Sydenham, England, and being required to report upon the progress of electric lighting, made as strong a report as I could in favor of this innovation. Whether this report had any weight or not, of course I do not know, but it seems that most of the objections which were raised against electric light proved unfounded, for various systems are being introduced and are giving satisfaction, and so thoroughly satisfied are officers that the proper method of lighting ships is by electricity that few of them would to-day think, for one moment, of seeing the old days return with their antiquated, unpleasant and unhealthy methods of illumination. So may we look upon the application of electricity as a motive power to a great variety of uses on board ship, and that with far more certainty of operation, more ease in manipulation, than in many machines now used. Few people not acquainted with the actual conditions met with on board ship realize the number of small engines in use and the variety of purposes to which they are applied. Steam has superseded hand steering apparatus; steam ventilation takes the place of wind-chutes; blowers, exhaust fans, and pumping machinery are driven by steam; ashes are hoisted by its agency. Shell hoisting and gun training, which is now performed sometimes by hand and again by pneumatic, hydraulic, or steam apparatus, will certainly, sooner or later, be better done by means of electro-motors. In fact we have been asked already by the Department to submit designs for operating the new 8-inch rifle gun for the Chicago, and are now working on these; the motor will be carried beneath the gun inside the carriage and the training will be under perfect control. Of course I do not say that the first experiment of this kind will be entirely successful, or that it will be devoid of objections. A perfect apparatus in this, as in any other line, must be developed by the process of evolution. It is not always possible to foretell every condition which will be met; but failures are simply the keys to success. The hoisting of shell and other ammunition, now done laboriously and uncertainly by hand, can be better done by positive acting electro-motors which will be under perfect control. Centrifugal pumps, with their rotary movement and high speed, and likewise fans and exhausters, both for ventilation and for forced draft in the furnaces, will be run by motors. It may be urged that there is a liability of accidents occurring with apparatus of this nature. In answer we can say that duplicate parts are easily carried and injured portions quickly replaced—if anything, more quickly than in any steam apparatus. One of the great advantages of the use of electricity for these purposes will be the avoidance of a great deal of heat now caused by carrying steam pipes all over the ships. Steam steering gear is now operated in a clumsy, uncertain method from the forward and after pilot houses by long lines of countershafting and gearing which, because of the general structure of the ship, cannot be other than objectionable. The electro-motor will replace this gearing in the near future, and so it will go on and eventually replace the steam apparatus itself. I do not think I can be rightly accused of speaking merely as an enthusiast, but may fairly claim to understand some of the conditions which obtain in ship life, and I feel warranted in expressing my own confidence that the future will solve every difficulty which the application of electricity to classes of motive power I have mentioned on board ship may demand. One of the great advantages in the use of electricity on board ship is the ease with which the conductors may be handled and run as compared with steam pipes, and also the facility with which they can be replaced in case of accident. The generating apparatus can be placed well out of the range of shot and shell, and easily protected. Another field for electric motors on board ship is in making repairs. To-day, if a drill is to be operated, a new bolt hole made, or any other work requiring tools of this character, they must be operated by a slow, tedious handgear; whereas a portable motor, with its flexible shaft and brace, can be introduced in the most out of the way part of boilers and engines, and work there performed which, were it done in the ordinary method, would require extensive preparations involving, possibly, the removal of heavy parts of machinery. Torpedoes can be operated as well as controlled by electricity. Diving operations and repairs to the ship's skin under water and in dock, repairs to armor, turrets, and to gun carriages can all be facilitated by the use of electric motors.

The methods of making these various applications of electric power may well receive the careful thought and criticism of all officers who desire the best good of the service, and I have no doubt but that many most valuable suggestions will in the future come from those who to-day look with conservative doubt upon the practicability of these proposals.

DISCUSSION.

THE CHAIRMAN.—*Gentlemen*:—There is no practical application of electricity that is now attracting more attention or is of greater importance than the transmission of power by electricity. The telephone may be greatly improved, but it has taken its place as a successful invention and an indispensable instrument in conducting the ordinary affairs of life. It is not improbable that in a few years the electric motor will be made more useful than the telephone.

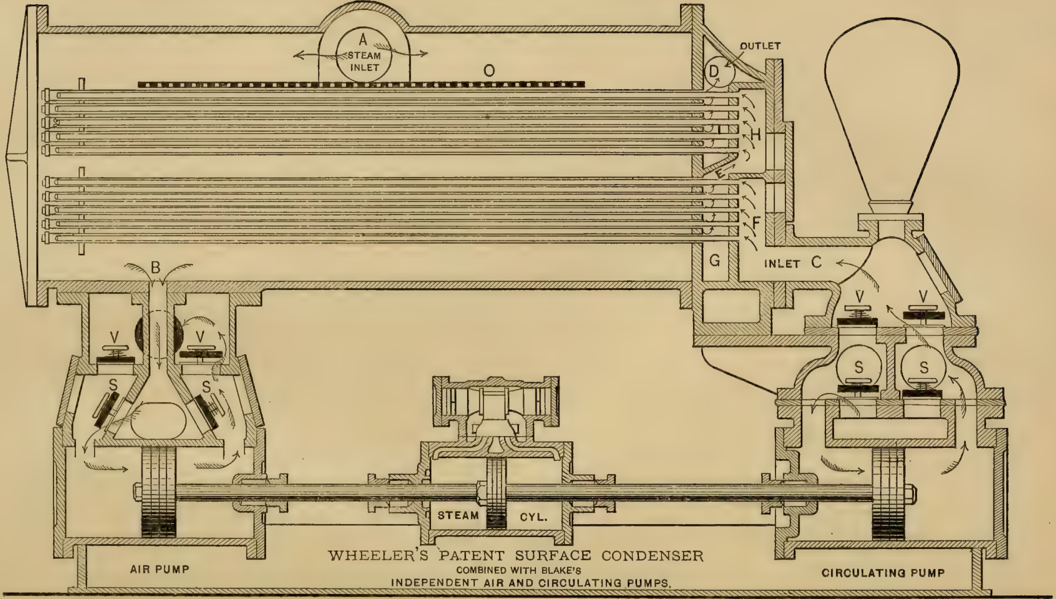
The science of electricity is so far advanced that no ignorant man will by accident hit upon a successful motor. Such a motor must be constructed in strict accordance with scientific principles. To be successful in these days of close competition it must be more than almost correct—it must be exactly right. It will be the result of the thoughtful work and experiment of an ingenious man well trained in modern science.

We are very fortunate in having had the opportunity to listen to one so thoroughly competent, so ingenious, so enthusiastic, and so successful as the lecturer of this evening.

The Naval Academy is to be congratulated that one of its graduates is in a position to return and, in this building, where he received his first theoretical and practical training in physical science, speak with authority as one of the foremost inventors and investigators in this branch of electrical science.

The subject is now before the Institute for general discussion. Mr. Sprague will, I doubt not, be happy to answer any questions that members of the Institute may wish to ask.

After some discussion of the feasibility of transmitting power over great distances, and of methods for testing the efficiency of motors, a vote of thanks, on the motion of Commander P. F. Harrington, was extended to Mr. Sprague for his valuable and instructive paper. The meeting then adjourned.



WHEELER'S PATENT SURFACE CONDENSER
COMBINED WITH BLAKE'S
INDEPENDENT AIR AND CIRCULATING PUMPS.

FIG. 1.

PROFESSIONAL NOTES.

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THE WHEELER SURFACE CONDENSER.

By W. F. Worthington, P. A. Engineer, U. S. N.

This condenser (Fig. 1) is similar to that patented by Mr. Loftus Perkins and described by him in a paper* read before the Institute of Mechanical Engineers in England.

The principal feature is the arrangement of one tube within the other, the circulating water passing through the inner tube and returning through the space between the tubes. It is readily seen, by inspection of the figure, that with this system the weight of the tubes and contained water will be slightly greater per square foot of cooling surface than it is with the ordinary arrangement of the tubes, and the weight of the remainder of the condenser about the same. The advantages to be expected are: first, increased efficiency of the tube surface; second, decreased work to be done by the circulating pump. With regard to the first advantage, extensive experiments were made by Joule† with apparatus similar in arrangement to this condenser, but differing in the unimportant detail that the steam passed inside and the water outside of the condensing tube. The experiment in which the condensing surface was most efficient showed that nearly 32 pounds of dry steam, entering the condenser at 30 pounds pressure, could be condensed per hour per square foot of surface with the injection at 44° F., discharge 90° F., hot well 122° F., and a vacuum of 26 inches maintained. This result is much in excess of those attained with the ordinary form of condenser, in which the tube surface is calculated to condense about 9 pounds of steam per square foot per hour,‡ and 13 pounds per square foot per hour is considered very fair work§ when the injection is 60° F. and feed 120° F. Joule's experiment referred to was made with a clean copper tube, but further experiments showed that the material, whether copper, iron, or lead, and the thickness within reasonable limits, made no practical difference. The principal difficulty in the conduction of heat arose from a film of water adhering to the tube surface, and any means adopted to prevent this largely increased the efficiency. The arrangement adopted by Wheeler is well calculated to compel a circulation at the tube surface and may fairly be expected to give excellent results.

With regard to the second advantage. Joule found that with equal weights of circulating water the weight of water condensed was increased by diminishing the space between the inner and outer tube, and in one case, when the space was decreased from 0.325 inch to 0.06 inch, the weight of condensed steam

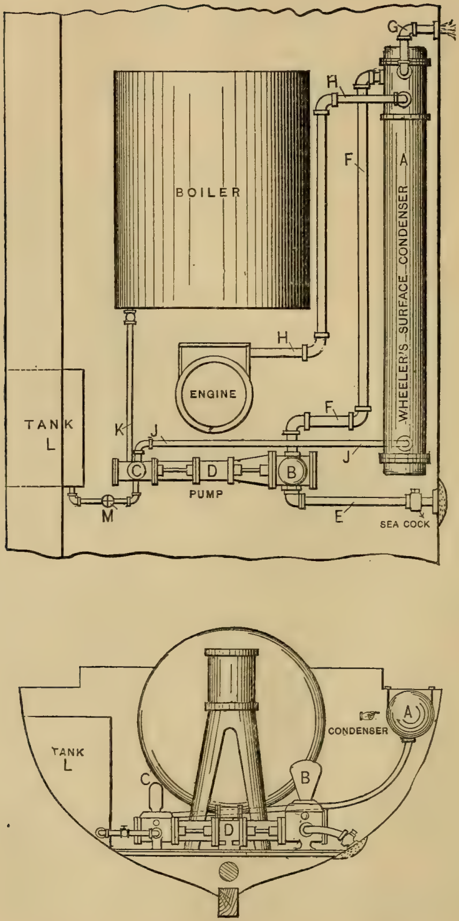
* Engineer, London, June 8, 1877.

† Scientific Papers of J. P. Joule, London, 1884.

‡ Die Schiffsmaschine, Busley, Kiel, 1883.

§ Manual of Marine Engineering, Seaton, London, 1883.

FIG. 2.


G
H
F
A
WHEELER'S SURFACE CONDENSER
BOILER
H
ENGINE
TANK L
K
J
F
J
C
D
B
PUMP
M
E
SEA COCK
A
CONDENSER
TANK L
C
B
D

was nearly doubled, while the weight of circulating water remained the same. The increase of the hydraulic head necessary to force the water through the tubes in the second case was very little, so that the saving in work done by the circulating pump with Wheeler's arrangement would probably be considerable. Furthermore, Joule found that by placing between the inner and outer tube, wire coiled in form of a helix to give a rotary motion to the water, the efficiency of the condensing surface was still further increased without materially affecting the hydraulic head required to force the water through the tubes, a fact which goes to show that a large part of the work done by the circulating pump with the ordinary form of condenser is wasted.

Experiments with a small condenser of the Wheeler type* with 4.27 square feet of tube surface showed nearly 102 pounds of steam condensed per square foot per hour, the injection being 56½° F., discharge 98° F., hot well 138° F., vacuum 24½ inches. This is a much better result than any obtained by Joule with the apparatus before mentioned. The difference may be partly accounted for if the steam was very wet, while that in Joule's experiments was known to be quite dry. Also the ratio of length to diameter of the tubes may have been better than in Joule's apparatus, it being well known that the evaporative efficiency of locomotive boilers is considerably affected by slight changes in these proportions.

One of the advantages of the Wheeler condenser is the ease with which the tubes may be removed for cleaning or renewal. An eminent authority† says that facility for cleaning the tubes is the principal point to be considered in designing a condenser.

Another advantage is that the tubes being screwed into the tube sheets and free on one end, there is no trouble from "crawling," and no packing to get leaky if the condenser is unused for a long period, as often occurs with naval vessels, or to be injured by accidental overheating of the condenser or by boiling to clean the tubes.

The body of the condenser shown in the figure for use on land is made of cast iron, but for use on shipboard these condensers are also made of steel, wought iron, or rolled brass plates. The cylindrical form of cross section allows the weight to be reduced to a minimum.

Fig. 2 shows a plan and elevation of the "light-weight" condenser adapted for yachts, launches, etc.

COLLISION, OR GROUNDING MAT.

By Commander G. King Hall, R. N.

[*Reprinted from Journal of the Royal United Service Institution.*]

As an officer who has served some years as First Lieutenant and Commander, I am convinced that the present collision mat, 12′ by 12′, is of little practical use, and those who know the difficulty of placing these mats and the time required—not to getting it over for drill purposes, but of accurately placing it—will agree with me that if a ship be rammed, and a serious hole made in her, by the time the mat was placed she would be full of water.

I would propose that mats of double No. I canvas should be, when at sea (if considered advisable, in harbor), kept permanently rolled and stopped up on the outside of ship ready for immediate use.

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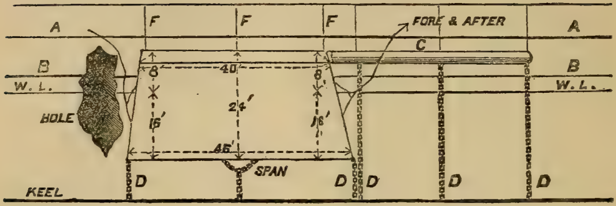
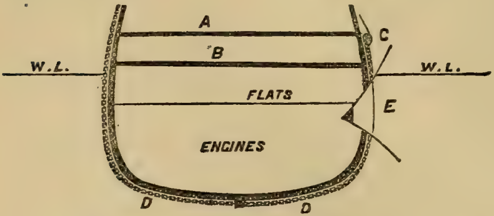
* American Machinist, May 15, 1886.

† Modern Marine Engineering, Burgh, London, 1867.

SHANNON.

(Abreast engine room.)





A	Upper Deck.	*C*	Mat rolled up.	*E*	Ram of Shannon.
B	Main Deck.	*D D*	Bottom chains.	*F F*	Tricing lines.

Scale $\frac{1}{32}''$ to a foot.

DIMENSIONS OF MAT.

Head, 40 feet long, and has a wire jackstay secured to bolts in ship's side, about 8 feet above water line.

Depth of Mat, about 24 feet, giving about 16 feet under water, the leach having a short fore and after in it, and end kept out when mat is rolled up, ready for immediate use.

Foot, 46 feet (so that the mats should overlap if by any chance the ship was rammed exactly between two mats); and to the foot are attached two iron round bars, 2 inches in diameter (each weighing about 230 pounds) and 23 feet long.

Bottom chains, going from each end of mat and one from the centre, connected by wire or chain span to the two inner ends of bars, consequently each mat would have three bottom lines.

Brails or tricing lines for tricing up foot when required.

In most of our large ships, four of these mats a side would be sufficient (in some of our smaller ironclads, such as the Shannon, three would be ample); four of these mats would cover a space of 160 feet, where the large compartments of ship are, as both forward and aft ships are so much protected by cellular compartments and also by the "run" of ship.

These mats should be always kept on at sea, especially when expecting an engagement; and if in an action the ship were rammed, or a hole made by a Whitehead torpedo, all that would be required would be to cut the straps (or, if fitted with tumblers, slip the foot), and the mat would then fall into its place, and steady taut the bottom lines; this could be done in two minutes; no bother in the middle of an action about whips, bottom lines, fore and afters, all to be bent on and perhaps foul, in the excitement of moment and difficulty of placing mat under fire.

If ship grounded and a large hole were made more than 16 feet under water, the head of mat can be at once cleared away and mat lowered and hauled over hole.

N. B.—These dimensions are only approximate, and might, on trial, require some slight modifications.

I believe if Vanguard had possessed these mats she would have been saved from sinking.

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REPORT ON THE PERMISSIBLE LIMITS OF ELECTRICAL RESISTANCE OF SERVICE FUZES AND DETONATORS.

Torpedo Station, Newport, R. I.,
March 5, 1887.

Sir :—In fixing the limits of electrical resistance for fuze bridges, the service for which they are intended and the firing apparatus to be used with them must be taken into consideration.

The ordinary uses to which electrical fuzes, detonators and cannon primers are put in the service at the present time, are the firing of a single torpedo from a boat, one to four torpedoes from a ship or a broadside battery. Ten may be considered as the maximum number of guns in the broadside of any ship in our service, and the introduction of high-powered guns will probably decrease this number.

The firing apparatus issued to the service are the Farmer's dynamo machines, pattern A and C, and the ship's and boat's firing batteries of six and four M. C. L. cells respectively.

As some vessels are furnished with a boat's outfit only, the A machine and ship's firing battery are not always found on board. The boat's battery is more especially designed to fire a single torpedo from a boat, and as it polarizes rapidly on being used it is not suitable for experimental purposes. It was therefore decided that a fuze bridge of such resistance that ten of them arranged in series might be rapidly and quickly fired by the C machine would best answer the requirements of the service. On this basis the experiments were conducted.

Farmer's C machine having an average electro-motive force of eight volts and an internal resistance of four ohms, has generally been considered as capable of firing from eight to ten fuzes of standard resistance (.62 ohm to .68 ohm, both inclusive) arranged in series, or a single fuze through 1500 feet of Siemens cable such as now used in the service. Using the standard bridge of iridin-platinum wire (90 per cent platinum, 10 per cent iridium) $\frac{3}{16}$ inch long and .002 inch diameter, a current of .6 ampere, which gives a hot resistance of 1.15 ohms to bridge, is necessary to instantly fire gun-cotton, which is used as priming. Neglecting the resistance of leading wires, the C machine is found theoretically capable of firing eight standard fuzes arranged in series. It may be stated that a less current, as, for instance, .5 ampere, is sufficient to fire gun-cotton, but requires a sensible time.

During the experiments it was found that the C machine would practically fire ten fuzes of standard resistance arranged in series, at apparently the same instant. In twelve experiments of this nature, whether the bridges were made up into igniters or simply primed with gun-cotton, there were no failures. When a bridge of .59 ohm resistance or less was introduced into the series there were frequent failures, though as a rule when the resistance did not vary much from the standard all the bridges fired. The same may be said of bridges having a resistance greater than standard.

We have not been able to explain the cause of failure in any special case, but a general explanation may be given as follows. In the manufacture of bridges of any standard resistance, variations in resistance may be due to—

1st. Errors in measurement of length of bridge.

2d. Difference in amount of solder used to fastened ends of bridge.

3d. Solder or foreign material adhering to the bridge at the middle or near the ends.

4th. Errors in measurement of bridge resistance due to differences in temperature and humidity of atmosphere.

These errors are to a certain extent unavoidable, but are reduced to a minimum when an experienced workman is employed in the manufacture of the fuzes. It will be seen from the above that a bridge of a certain length may have the same resistance as a longer one having a greater amount of solder at its ends, or solder or foreign material at its middle or near the ends. Also that a bridge having a certain resistance at the time of measurement may have greater or less resistance when required for firing. Bridges having the same resistance but differing in accuracy of construction may, therefore, require different conditions for firing, and bridges of exactly the same construction, measured at different times, may have different resistances. Moreover, in any experiments where a dynamo machine is used, differences in electro-motive force must occur, owing to the variations in turning the crank. Like variations in electro-motive force will occur in the use of a battery which is not constant.

Far better results were obtained when the bridges were simply primed than when made up into igniters. This is explained as follows: When igniters are used, the bridges which are first raised to the required temperature are broken by the explosion of the igniters, thus preventing the others from firing through delayed action. When simply primed with gun-cotton the bridges are seldom burned off, and a continuous turning of the crank of the machine is only necessary to fire all.

As a result of our experiments we are of the opinion that bridges of the wire now in use having an electrical resistance of not more than .70 ohm nor less than .60 ohm are best adapted to the requirements of the service. A somewhat smaller limit should be adopted as an element of safety, because errors are likely to occur in the measurement of resistance from the causes heretofore stated, and because certainty of action is the most important consideration in torpedo practice. The present standard bridge appears to answer all the requirements, and, if the fuzes be properly made by an experienced workman, little or no waste will result from its adoption.

To conclude, we are of the opinion that the present standard bridge, having an electrical resistance of .62 to .68 ohm, both inclusive, is the best, both theoretically and practically, and do therefore recommend that its use in the service be continued.

LIEUTENANT J. A. SHEARMAN, U. S. N.
ENSIGN G. W. DENFELD, U. S. N., *Recorder.*

COMMANDER C. F. GOODRICH, U. S. N.,
Inspector in Charge.

The following is a list of the experiments upon which the above report is based. In each case ten igniters or bridges were connected in series and joined to the C machine by short leading wires.

The tables are arranged in five columns:

The 1st showing the experiment number.

2d, the resistance of the bridge.

3d, the number of igniters or bridges used of resistance shown in the 2d column.

4th, the place of each bridge in the circuit numbered from the positive wire.

5th, the results.

Experiment No.	Resistance.	No. in Series.		Place in Circuit.		Results.
		Igniters.	Bridges.			
1	.62	1		10		Fired.
	.64	5		1, 2, 3, 4, 5		“
	.65	1		9		“
	.66	2		6, 7		“
	.68	1		8		“
2	.62		2	9, 10		“
	.63		1	4		“
	.64		1	5		“
	.65		2	1, 3		“
	.66		2	2, 6		“
	.67		1	7		“
	.68		1	8		“
3	.62		1	6		“
	.63		2	1, 5		
	.64		1	9		
	.65		2	2, 8		
	.66		1	7		
	.67		2	3, 4		
	.68		1	10		
4	.62		2	2, 4		Fired.
	.64		2	1, 5		“
	.65		3	6, 9, 10		“
	.67		2	3, 8		“
	.68		1	7		“
5	.62		2	1, 2	9, 10	“
	.63		1	3	8	“
	.64		1	4	7	“
	.65		2	5, 6	5, 6	“
	.66		1	7	4	“
	.67		2	8, 9	2, 3	“
	.68		1	10	1	“
6	.62		2	1, 2	9, 10	“
	.63		1	3	8	“
	.64		1	4	7	“
	.65		2	5, 6	5, 6	“
	.66		1	7	4	“
	.67		2	8, 9	2, 3	“
	.68		1	10	1	“
7	.62		4	2, 7, 8, 10	1, 3, 4, 9	“
	.63		2	4, 6	4, 5	“
	.65		1	5	6	“
	.66		1	9	2	“
	.67		2	1, 3	8, 10	“

Experiment No.	Resistance.	No. in Series.		Place in Circuit.		RESULTS.
		Igniters.	Bridges.			
8	.62		2	6, 8	3, 5	Fired.
	.64		1	1	10	"
	.65		3	4, 5, 10	1, 6, 7	"
	.66		2	3, 9	2, 8	"
	.67		2	2, 7	4, 9	"
9	.63		2	3, 10	1, 8	"
	.64		3	4, 7, 9	2, 4, 7	"
	.66		1	6	5	"
	.67		3	1, 5, 8	3, 6, 10	"
	.68		1	2	9	"
10	.62		9	{ 1, 2, 3, 4, 6 7, 8, 9, 10		"
	.63		1	5		"
11	.64		2	1, 2	9, 10	"
	.65		4	7, 8, 9, 10	1, 2, 3, 4	"
	.66		4	3, 4, 5, 6	5, 6, 7, 8	"
12	.67		5	1, 4, 5, 7, 9		"
	.68		5	2, 3, 6, 8, 10		"
13	.61	1		10		"
	.63	1		1		"
	.64	3		2, 3, 4		"
	.65	5		5, 6, 7, 8, 9		"
14	.60	1		1		"
	.63	1		2		"
	.64	3		3, 4, 5		"
	.65	5		6, 7, 8, 9, 10		"
15	.60	1		1		"
	.63	1		2		"
	.64	3		3, 4. 5		"
	.65	5		6, 7, 8, 9, 10		"
16	.59	1		1		Failed. Afterwards was fired by itself.
	.63	1		2		Fired.
	.64	3		3, 4, 5		"
	.65	5		6, 7, 8, 9, 10		"
17	.57	1		1		"
	.63	1		2		Failed. Afterwards was fired by itself.
	.64	3		3, 4, 5		Fired.
	.65	5		6, 7, 8, 9, 10		"
18	.39	1		1		"

Experiment No.	Resistance.	No. in Series.		Place in Circuit.		Results.
		Igniters.	Bridges.			
18	.62	2		2, 3		Fired.
	.63	5		4, 5, 6, 7, 8		"
	.64	2		9, 10		"
19	.27	1		10		Failed. Afterwards was fired by itself.
	.63	1		1		Fired.
	.64	3		2, 3, 4		"
	.65	5		5, 6, 7, 8, 9		"
20	.64	2		1, 2		
	.65	5		3, 4, 5, 6, 7		
	.66	2		8, 9		
	.77	1		10		
21	.63	1		1		Fired.
	.64	3		2, 3, 4		"
	.65	2		5, 6		"
	.66	3		7, 8, 9		No. 9 failed. Afterwards fired singly.
	.77	1		10		Fired.
22	.62		2	6, 8	3, 5	"
	.65		3	4, 5, 10	1, 6, 7	"
	.66		2	3, 9	2, 8	"
	.67		2	2, 7	4, 9	"
	.77		1	1	10	"
23	.63	1		2		"
	.64	3		3, 4, 5		"
	.65	5		6, 7, 8, 9, 10		"
	.79	1		1		"
24	.61		1	10		"
	.62		1	9		"
	.63		1	8		"
	.64		1	6		"
	.65		1	3		"
	.66		2	1, 4		"
	.67		1	2		"
	.68		1	5		"
	.69		1	7		"
25	.60		1	8		"
	.61		1	7		"
	.62		1	6		"
	.63		1	10		"
	.64		1	5		"
	.66		1	9		"
	.67		1	3		"
	.68		1	1		"

Experiment No.	Resistance.	No. in Series.		Place in Circuit.	Results.
		Igniters.	Bridges.		
25	.69		1	4	Fired.
	.70		1	2	"
26	.59		1	2	"
	.60		1	3	"
	.61		1	5	"
	.62		1	4	"
	.63		1	10	"
	.67		1	1	"
	.68		1	6	"
	.69		1	7	"
	.70		1	8	"
	.71		1	9	"
27	.59		1	8	"
	.60		1	9	"
	.61		1	6	"
	.62		1	7	"
	.63		1	1	"
	.67		1	10	"
	.68		1	2	"
	.69		1	3	"
	.70		1	4	"
	.71		1	5	"
28	.61	3		1, 2, 3	"
	.62	7		4, 5, 6, 7, 8, 9, 10	"
29	.57		1	5	"
	.62		2	9, 10	"
	.63		1	4	"
	.65		1	3	"
	.66		1	2	"
	.67		1	7	"
	.68		1	8	"
	.70		1	6	"
	.80		1	1	"
30	.50		1	1	"
	.61		1	2	"
	.62		1	3	"
	.63		1	4	"
	.65		1	5	"
	.66		2	6, 7	"
	.68		1	8	"
	.69		1	9	"
	.70		1	10	"
31	.50		1	1	"

Experiment No.	Resistance.	No. in Series.		Place in Circuit.	Results.
		Igniters.	Bridges.		
31	.61		1	2	Fired.
	.62		1	3	“
	.63		1	4	“
	.65		1	5	“
	.66		1	6	“
	.67		1	7	“
	.68		1	8	“
	.69		1	9	“
	.80		1	10	“
32	.41		1	1	No. 1 failed to fire, but fired singly.
	.61		1	2	Fired.
	.62		1	3	“
	.63		1	4	“
	.65		1	5	“
	.66		1	6	“
	.67		1	7	“
	.68		1	8	“
	.69		1	9	“
	.94		1	10	“
33	.57		1	5	“
	.61		1	2	“
	.62		1	10	“
	.63		1	4	“
	.65		1	3	“
	.67		1	7	“
	.68		1	8	“
	.69		1	9	No. 8 failed. Afterwards fired, connected up in same series by turning crank of machine rapidly.
	.70		1	6	
	.80		1	1	
34	.64	2		1, 2	Fired.
	.66	1		3	“
	.68	1		4	“
	.69	4		5, 6, 7, 8	“
	.70	1		9	“
	.71	1		10	“
35	.50	1		1	“
	.53	2		2, 3	“
	.55	1		4	“
	.56	1		5	“
	.59	1		6	“
	.62	3		7, 8, 9	“
	.64	1		10	“
36	.55		5	1, 2, 3, 4, 5	Fired—also when reversed.
	.75		3	6, 7, 8	

Experiment No.	Resistance.	No. in Series.		Place in Circuit.		Results.
		Igniters.	Bridges.			
36	.76		2	9, 10		
37	.55		1	1		Fired—also when reversed.
	.56		1	2		
	.57		1	3		
	.58		1	4		
	.59		1	5		
	.71		1	6		
	.72		1	7		
	.73		1	8		
	.74		1	9		
	.75		1	10		
38	.55		1	3		Fired—also when reversed.
	.56		1	2		
	.57		1	10		
	.58		1	7		
	.61		1	1		
	.69		1	5		
	.70		1	8		
	.72		1	4		
	.74		1	6		
	.75		1	2		
39	.57		1	1	10	Fired.
	.58		1	2	9	"
	.59		1	3	8	"
	.60		2	4, 5	6, 7	"
	.61		5	6, 7, 8, 9, 10	1, 2, 3, 4, 5	"
40	.74		3	1, 2, 3		Fired—also when reversed.
	.75		3	4, 5, 6		
	.76		4	7, 8, 9, 10		

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PNEUMATIC WATER ELEVATING APPARATUS FOR SUPPLYING SHIPS WITH WATER.

(Invented by ARMISTEAD RUST, Naval Cadet, U. S. N.)

The apparatus consists of a series of tanks in the after hold for containing hot and cold fresh water and the waste water from the bath-tubs and basins of a ship. After a tank is filled with water it is put in connection with a receiver filled with air of sufficient pressure to cause the water to flow up to the basins, or overboard when the proper cocks are opened. The air is compressed by a pump worked by an eccentric on the main engine shaft, or preferably by a separate engine.

The water in the hot-water tank is heated by a few turns of a steam pipe. It is proposed to use the waste water in case of fire by shutting the outboard connection and attaching a hose to a nozzle provided. Suitable gauges and safety valves are fitted to the tanks. W. F. W.

THE TACTICS OF INFANTRY IN BATTLE.

By Colonel Sir Lumley Graham.

[*Reviewed by Lieut. D. H. Mahan, U. S. N.*]

This interesting pamphlet, reprinted at the U. S. Artillery School, Fortress Monroe, contains a great deal of valuable information. It is well known that neither our Army nor Navy possesses any work on modern tactics. Regiments and brigades are still drilled according to Upton. The deployments and skirmishings as taught are much behind the present system of foreign tactics, and it is necessary that some step should be taken to remedy this state of affairs, to so change our tactics as to make them in some manner similar to those adopted by the military nations, France, Germany, and Austria.

Let us look at some of the general principles adopted by these three nations and see if they will not give food for thought to many of us.

"1. The relative value of the firearms (cannon and musket) and of the side arms (sword and bayonet) has been much affected by modern technical improvements. The firearm is now undoubted mistress of the battle-field, where everything is subordinate to it.

2. The formation of infantry for battle must be such as to favor to the utmost the effect of its own fire, and to minimize the damage done by that of the enemy. Within effective ranges everything must give way to these two considerations.

3. For the front or "firing line" the only formation, both in attack and defense, which meets these requirements, is a line of small sections extended in single rank (which are called a line of skirmishers), which from being at first very open becomes more and more dense as the antagonists come to close quarters, attaining at last almost the consistency of a line in close order.

4. This "firing line" has a very different mission to that of the old "line of skirmishers." The latter had only to prepare the way for the columns or lines and to supplement their efforts; the former, on the contrary, has to fight the battle out through all its stages to the very conclusion, being supported in doing so by the troops in close order.

7. A tactical body once thrown into a firing line on the offensive cannot be relieved; its remnants, great or small, will remain in the firing line to the end of the action.

8. The comparatively loose formations necessary in the present day render supervision and control on the part of superiors more difficult. Tactical dispositions will again do something to remedy this evil, but *thorough discipline and training will do more*, contributing, as they will, to the complete maintenance of the chain of responsibility, from the Commander-in-chief right down to the leader of the smallest squad in the fighting line.

9. The importance of the company as a battle unit is much increased, and *pari passu* the importance of the Captain as a commander.

13. The tactical desiderata for an ideal defensive position are: First and foremost, a clear field for fire, both to the front and flanks, for some three thousand yards; secondly, ground sloping gently downwards towards the

enemy; thirdly, well-secured flanks, and no prominent salient angles; fourthly, good cover for supports and reserves at a convenient distance from the fighting line; fifthly, good sheltered communications from the rear and along the position; sixthly, good positions for batteries in rear and on higher ground than infantry.

15. Good infantry need not fear the attack of cavalry, even if in extended order. As a general rule they should be able to maintain the formation in which they happen to be when threatened. To do otherwise will be only to play the enemy's game.

19. A mere passive defense will produce no great result. A commander when on the defensive must always be prepared to make a counter-attack at the right moment."

These selections teach us to undo much we have been taught to do. They bring to our notice that the ideas we still hold to in instruction are of but little use in action, and that the company commander now is the one on whom much of the onus of the fight will fall. The responsibility does not now rest with one or two men, but with all, from the Commander-in-chief to the private, and the responsibility being so much more divided, the instruction must be so much more extended and perfected.

The tactical desiderata give us the ideas we want; continual practice must be had to enable one to take advantage of the ideas taught. The styles of firing have changed so much now that the instruction must be changed and the soldier or sailor made almost an expert with the rifle, and especially with the repeating rifle. The instructions given must be with a view to a careful nursing of supply until the critical moment, the efficiency of group firing and the supreme importance of entire attention to orders given by the company officers.

The last but by no means the least important article (19) shows how very important it is for the Commander-in-chief of the force to be one capable of seizing upon any and every opportunity that chance or bad management on the opposing side may offer to him by which some advantage may be gained. It shows that a careful selection should be made in giving command of an expedition, not giving it to rank, but to the one known to be the best military commander.

From page 5 to 8 the details of infantry fighting are dwelt upon, considering the distribution of a battalion acting by itself on the offensive. In these pages the divisions of the company are given (each nation having a paragraph to itself), and its actions as the "advanced company in the first stage of the fight." Also "the rest of the battalion during the first stage." Page 8 commences the second stage of the fight, which supposes the attacking force to be about 500 yards from the enemy's position. "Put off the moment of opening fire as long as you can, and get as near the enemy's position as possible before doing so," is the German idea. The French say at 650 yards fire should be opened along the whole line, while Austria leans more to the German idea and only admits of general firing at 300 paces. The kind of fire employed by Germany is either volleys (those of the line or groups), individual (or skirmishing) fire, and rapid independent fire, but it is insisted that from the moment fire is opened it should become general, because the object of the assailant is to subdue the defender's fire so as to facilitate his own advance. France only allows rapid independent fire with the 200-metre sight. Austria, while recognizing only one sort of fire when in extended order, that of individual firing, yet, in the case of men in close order, admits of volleys and of independent firing. Pages 11 and 12 are devoted to gaining ground under fire; page 13 to supports and reserves under fire, and to the assault. The storming distance as considered by Germany is not less than 200 yards on open ground, and we would quote these words: "The maximum distance to be traversed in the final charge must depend upon the physical powers of the assailants, as there must be no check. This rush must be in one inning. The maximum distance must therefore greatly depend upon whether the ground is flat or whether there is a steep gradient, again, whether the soil be at the time light or heavy." The French say the assault should commence at the point beyond which the assailant can make no further progress by the effect of his firearms alone. Austria considers 80 to 100 paces as the maximum distance to be traversed when storming. "By whom will the order for the charge be given?" Germany gives it to the leaders of the foremost bodies. France gives it to no specified person, but seemingly to the battalion commander. Austria allows it to the leaders of the fighting line. The execution of the assault and after the assault are referred to on pages 14 and 15, and this rule is held to by all: "Infantry not to pursue the retreating enemy, but only to fire after them. If woods or villages are carried, their further borders should be occupied at once. The interior should be well searched by a portion of the reserve, which should at once rush up to the position, the remainder joining in the fire on the retreating enemy."

Pages 16 to 21 are given to the "single battalion on the defensive," and on page 17 we find these words: "A commanding officer has thus to provide a sufficiently strong fighting line; next, to feed and reinforce it at need; thirdly, to keep in hand a general reserve; fourthly, to set apart a special body to execute the counter-attack when the proper time comes; and, lastly, to make his tactical dispositions in such a manner as to prevent as far as possible, or, at any rate, to delay to the utmost any intermixture of units." "A defensive action resolves itself into two stages: 1. that of distant fire; 2. that of near fire. The boundary between the two being the moment when the fighting line of the assailants is brought to a standstill and begins to reply effectively to the fire of the defenders." Page 17 also considers the "first stage of the defense." "The object of the defender is to delay the assailant and to make his approach to storming distance as difficult as possible. This must be the work of the rifle, and the question is how best to use it." The Germans tend to volley firing at this stage, first, against deep columns exposing themselves, then, against company columns and lines, lastly, against skirmishers. The French fire, part against skirmishers and the remainder at the supports and reserves. Pages 18 and 19 dwell upon the second stage of the defense, "which reaches its climax when the assailant is preparing to storm. At that moment the defender must bring every disposable rifle into action, except the reserve kept in hand for a counter-attack. Troops brought up at this moment should be in close order; they risk little, for the enemy will be stopping his fire to make his assault, and they will be more under control. This is specially the moment, and one of the few moments, when rapid independent fire is advisable." Page 19 also refers to the counter-attack and further measures. "The necessity of combining the offensive with the defensive, and of not trusting to a mere passive defense, is universally admitted. The question is, When and how is the defender to take the offensive?" Page 20 gives the ideas of the three nations upon this part of the action if the defense is a successful one, or, if unsuccessful, sets forth the different modes of withdrawal. Page 21 sums up a defensive action as follows:

"1. Reconnaissance of the position. Construction of defensive works. Patrols sent out for security.

2. Occupation of the position. As a rule, two companies side by side, each divided into fire-line and supports. The other companies in reserve on one or both flanks.

3. Commence firing volleys at long ranges on marks easily hit. If good opportunities offer, the supports are moved up into the fire-line for short periods.

4. At short ranges independent fire is used. Supports reinforce the firing-line, coming up as a rule by groups.

5. The enemy makes his assault. The defender's reserves move up into line and fire volleys. If possible, a counter-attack upon the flank of the enemy.

6. The defenders pour a heavy fire upon the retiring enemy, or themselves retreat by successive echelons."

This finishes the consideration of the single battalion. A short space is given to "Infantry against Cavalry," in which all agree that "if attacked by cavalry, infantry should allow itself to be as little disturbed as possible from the formation in which it happens to be. Skirmishers may even receive cavalry without closing if the ground be at all favorable to them. A body of troops in close order had best receive cavalry in line if already deployed or if it have time to do so." Germany has three forms of squares for this defense—battalion, company, and group or rallying squares. France uses company squares, but neither of the others. A battalion in open column forms company-columns and echelons them, or forms line. A battalion in line of company-columns, echelons the companies so that they may support one another. Austria uses rallying squares for skirmishers and company squares for supports, but a battalion attacked by cavalry forms the same as the French. From page 22 to page 28 a battalion forming part of a larger body is considered; on the offensive, (1) battalions in rear line; (2) extent of line; (3) the assault; on the defensive, battalions in rear line. From page 28 to page 37 the question of infantry battle tactics in Russia is considered, and on page 37 is given a comparison between the French and German infantry tactics of the present day, written by an experienced French officer, and which will give to any one interested in tactics for the foot soldier many excellent points. The pamphlet, taken as a whole, is one that should be carefully studied, and it should be in the possession of every one whose duty it may be to have charge of a landing force in either this or any other country. Naval officers can study it to great advantage, for the time is near when we must change our present system to one comprising as principles many of the points laid down in this work.

COMBUSTIBLE FOSSILS, REFRACTORY MATERIALS, AND THE IRON INDUSTRY AT THE NATIONAL EXPOSITION OF TURIN IN 1884.

BY L. ADAMI, COLONEL OF ARTILLERY.

(Supplement to the *Rivista d' Artigliera e Genio.* Translated by W. F. WORTHINGTON, P. A. Engineer, U. S. N.)

Bituminous coal is not found in Italy; the only combustible fossils are anthracite coal and lignite. There are about fifteen localities in Italy where anthracite has been found, but none of them of much commercial importance, as the anthracite is generally of indifferent quality, containing much earthy matter, is in small and distorted veins, and difficult to excavate.

Lignite, on the other hand, is found in abundance and in many localities, and being in some cases of excellent quality, gives rise to an industry of considerable importance. There is one mine, only slightly explored as yet, which contains lignite of such good quality that many scientists consider it bituminous coal. With regard to calorific values, three units of the best lignite are equal to two of ordinary bituminous coal, and of the inferior lignite two units are equal to one of bituminous coal. Besides inferiority in calorific value, some of the lignites have other qualities, such as giving off great volumes of smoke, unpleasant odor, sulphur sufficient to damage fire boxes, also taking fire spontaneously, crumbling and falling through the grate. Many of them produce much clinker which sticks to the grate. The best kinds of lignite are adapted for use in steam boilers for stationary engines, metallurgical, glass, terra-cotta, cement and other furnaces. Other kinds are even better for the same purposes after having been previously artificially dried. The worst kind may be used for the same purposes, but when used to convert pig iron into wrought iron or steel must be burned in a Siemens regenerator or other such furnace. They are not adapted for use in cupolas.

Conglomerates.—The name conglomerate (agglomerato) is given to bricks composed of coal dust mixed with tar (catrame) and subjected to pressure. The bricks are adapted for use in stationary and locomotive boilers and in other industries. Their principal advantages are the small losses which occur in transport, the convenience of handling, and the small space occupied. Their calorific value can never exceed that of the best bituminous coal, and they are necessarily more costly. In Italy this manufacture is very limited, and only introduced to utilize the small quantity of dust from imported coal. The bricks are composed of coal dust and tar (brai-grasso), or of olive seeds (sanze), tar (brai), petroleum residue, schist (scisto), benzine, residual paraffine, stearine and other oleaginous materials. The latter composition, called the Rubino combustible, of which the principal ingredient (80 per cent to 90 per cent) consists of olive seeds, deserves special notice. There are about 500,000 tons of "sanze" produced annually, and the patentee claims that this would furnish enough of his fuel to supply all the requirements of the country both on land and sea. It is to be noted, however, in this connection that the annual importation of bituminous coal is 2,000,000 tons. He claims for the fuel the calorific value of 6800 calories (bituminous coal about 7000—W. F. W.), that it is free from dust, saves the grates, furnaces and boilers, produces no clinker and contains no sulphur, and is 30 per cent to 50 per cent cheaper than other fuels, according to the locality. It should be remembered that much of the "sanze" is now used for fuel in the neighborhood of the oil factories, and if it was all bought up for the manufacture of bricks the price of the latter would rise considerably. Nine varieties of the fuel are produced, each adapted to a special purpose. Experiments made with the fuel in the furnace of a steam-boiler showed 8 kilos of steam at five atmospheres pressure, evaporated per kilo of the fuel, the cost of which latter was about one-half the cost of Cardiff coal. There was no trouble in managing the fire, the fuel did not adhere to the bars or form clinkers, burnt with a beautiful flame and little smoke, was readily lighted, and the bricks burnt regularly and uniformly. The ash was small in quantity, perfectly white, and easily disposed of.

Coke.—As there is no bituminous coal in Italy, the only coke produced is that left from the manufacture of illuminating gas, and is not useful for metallurgical purposes.

Turf.—The scarcity of combustible fossils and the increasing destruction of the forests render even the deposits of turf valuable. The use of this material only dates back about 25 years, but is now quite extensive, even being used in the Siemens regenerative furnace and steam boilers on land and on the lakes. Its calorific value is about the same as that of good lignite, *i. e.* about one-half that of bituminous coal. It occurs almost exclusively in the valley of the Po.

Conclusion.—In the arsenals the native fuels, with the exception perhaps of the Rubino combustible, are not fit to be used in the reverberatory furnaces (forni a riverbero) or in the muffles (forni a manica), but may be used for any other purposes.

Refractory Materials.—Graphite is found in some parts of Italy well adapted for making refractory crucibles, for use as a lubricant for machinery, and mixed with oil forms a varnish for iron. It is used principally, however, for the manufacture of pencils, and is also exported.

Fire Clay, Fire Bricks, and Clay Crucibles.—There is a serious deficiency in good fire clay. Most of the native clays soften at the highest temperature of the iron furnace, and are therefore not well adapted for making fire bricks.

The Iron Industry.—Italy is relatively rich in iron ores. Scarcely one-quarter of this is smelted in the country; the remaining three-fourths are exported. The reason for this is the small supply of good native coal and wood charcoal. The native cast iron, however, is of the best quality, and for the manufacture of cast iron guns, that from Lombardy is equal to the best Swedish pig.

[The paper concludes with a short account of the facilities for the manufacture of gun steel and projectiles at the time of the Exposition. Besides the few facts selected for this notice, the paper has full tables of the quantities and qualities of the various materials and the localities in which they are found, and altogether is well worth careful study by both friends and enemies of Italy, the capacity for manufacturing guns and machinery being at the base of a country's military strength.—W. F. W.]

AMERICAN STEEL FOR THE NEW CRUISERS.

Commander Robley D. Evans, U. S. N., Chief Inspector of material for the new cruisers, in conversation with a Washington newspaper correspondent, has made some interesting statements in regard to the quality of steel now being produced by our American manufacturers. As the subject is one of interest to the members of the Institute, we give in full his statements as printed in *The Iron Age* of June 16.

"I think the manufacturers of steel to supply the demands of the Government contracts will agree with me that the system of inspection and the high requirements of the physical properties of the material have done much to promote a higher standard of production than has ever been achieved in the United States. At first the manufacturers looked upon the inspections as unnecessarily severe, but since they have been gathering important lessons by experience they have commenced to realize that it has been to their advantage.

"Let us take the ship plates manufactured by the Park establishment, of Pittsburgh, for the Cramps, of Philadelphia. At first they had great trouble. After weeks of testing and intelligent manipulation the standard was reached, and they are now delivering plates of a better standard than any manufactured abroad. They are up to the best French, and better than the English plates.

"Now let us look at Carnegie, Phipps & Co. They at first experienced the greatest difficulty in the production of ship and boiler material. Now they are delivering the very first quality. I remember the first shoe plate for the cruiser Baltimore. It was 1¾ inches thick and considered an impossibility. After repeated experiments and personal attention I had the pleasure of congratulating the makers not only upon the successful rolling of the plate, but upon the highest and most satisfactory tests. They can now roll any number required without the slightest trouble.

"Now take rivets. The requirements in the specifications were so exacting that several firms declined the contracts. Oliver Brothers & Phillips, who make steel by the Clapp-Griffiths process, finally accepted. At first they met with doubtful success, but after a few weeks' drilling under the eyes of the inspectors they came up to all the requirements. They are now making the rivets right along up to standard. They admit that the Government inspection has not only been an advantage as bringing the steel up to a high standard, but that it has been of advantage to the workmen by teaching them to be careful."

"How about castings?"

"I was about to say that steel castings made under Government contracts surpass everything anticipated. Indeed, so marked has been the success in that direction that Mr. Cramp proposes to use steel castings in parts of ships where it was never used before. The castings for the stern-post and rudder-train and other parts of these vessels have been successfully made by the Standard Steel Casting Company, of Thurlow, and the Midvale Steel Works, of Nicetown, Pa. In fact, results have been achieved far beyond the claims of the most sanguine believers in steel castings.

"This is among the Eastern manufacturers. Now let us turn to the West. It is somewhat remarkable that the Pacific Rolling Mills, of San Francisco, considering the short time they have been in operation, are turning out steel for the California ship which in regularity of physical properties surpasses anything made by Eastern firms. The reports we have of 20 heats, averaging 20 tons to the heat, fall between 60,000 and 62,000 pounds ultimate strength, with an elongation of 28 per cent, 25 per cent being the maximum requirement.

"The steel for the frames and shapes made by the Pennsylvania Steel Company, at Steelton, and rolled by the Phœnix Iron Company, are also beyond what was looked for so soon after the Government work was undertaken.

"With all these practical results it can be said that the Government has done much for metallurgical production in the United States. Better material is being put into the new vessels for the Navy than has ever been put in any ship in the United States, and, as far as the records in our possession show, better than has been put in ships abroad. I think Mr. Cramp and Chief Engineer Melville will agree with me in this."

A record of the results of these inspections is being kept by Lieutenant F. J. Milligan, U. S. N. It will undoubtedly be of great value not only in giving a history of the material used in each ship, but from a scientific point of view.

C. R. M.

SYSTEM FOR SIGNALING TO AN APPROACHING VESSEL THE POSITION OF THE HELM.

This system, invented by Captain Staves, and for which he has received a medal at the Liverpool Exposition, and also the thanks of Lloyd and the Board of Trade, consists of two standards placed one on each bow and at such a height as to be clear of the sails. Each standard has at its top a light of the same color as the side light; *i. e.* green to starboard and red to port, as also a semaphore arm of the same color. The normal condition of these is, lights masked and arms down. If the helm is put to either side, on seeing a vessel approaching, the officer of the deck by working a lever either unmasks the corresponding light or raises the corresponding arm.

D. H. M.

BOOK NOTICE.

AZIMUTH: A TREATISE ON THIS SUBJECT. By Lieutenant-Commander Joseph Edgar Craig, U. S. Navy. New York: John Wiley & Sons.

We are pleased to acknowledge the receipt of "Azimuth: A Treatise on this Subject," by Lieutenant-Commander J. E. Craig. The masterly manner in which the subject is treated shows that the author has given the subject many hours of careful and faithful study, and the results arrived at show that the old time and generally accepted theories, as to the best positions of heavenly bodies for azimuth observations, have been derived more from snap judgments than from penetrating mathematical deductions. As the author remarks, ordinary observations at sea do not exact the best conditions of observation, but there are doubtless many cases in which too much labor cannot be given to obtain the best results, and the author has pointed out the way in which this accuracy may be reached.

The treatment of the various loci discussed and drawn shows a deep and thorough knowledge of the subjects involved, and commends itself to the mathematical mind as a lucid and graphic illustration of how such a subject as this may be opened to the observer who will devote a few hours to perusal and study.

We congratulate the author sincerely, not only on the subject-matter of his work, but on the attractive form in which he has presented it to the public.

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15TH ANNUAL SERIES, 1887, NO. 3. Studies of the ice in the harbor of Kiel. Hydrographic notes on voyage between Koepang, Island of Timor, to Cooktown. The Island Ascension. Notes on Benguela, Santa Maria Bay, and Mossamedes, on the west coast of Africa. The Island of Mackau, Corean Archipelago. Notes from the voyages of several German merchant captains. Report on the harbor of Zebu, Philippine Islands. Pauta Delgada, Island of St. Michael, Azores. Instruments for measuring currents, and current measurement in the Bosphorus. Deep-sea sounding in the North Atlantic. Current observations, temperature observations, North Atlantic. Tracks of typhoons around Japan, and hints for avoiding them. Rains in the Indian Ocean. Short notices. Tables of average temperature, meteorological and magnetic observations.

E. H. C. L.

SERIES 1887, NO. 4. Observations on the Earth's Magnetism by the Polar Expedition, 1882-3. The Malimba and Blundo Rivers, south coast of Africa. Expedition of the Fylla to Baffins Bay in 1886. Meteorological and Hydrographic Notes: Part V. Samana Bay, San Domingo, West Indies. Nimrod Sound, China. Geographical, Meteorological, and Hydrographic Notes. J. T. S.

BULLETIN OF THE AMERICAN IRON AND STEEL ASSOCIATION (quoting from the *Iron Trade Review*).

The use of petroleum as fuel.

This fuel is used successfully in the Bay State Steel Works, South Boston, Mass., but has been abandoned on the steamers of the Union Pacific Railroad. Dr. Kauffmann reports to the Russian Government that petroleum can be solidified into bricks and still retain its calorific properties. He says: "Petroleum, which is a hydrocarbon of the methane group, may be saponified just like the oils, fats, fatty acids, and wax, thus oxidizing the oil and combining it with soda or potassa salts. For this purpose the oil is heated and from one to three per cent of common soap is added, with which it is boiled for half an hour. The soap dissolves and the fluid turns suddenly to a hard, putty-like substance. It lights with difficulty, burns slowly without smoke, producing great heat, and leaving about two per cent of odorless, black, hard residuum."

W. F. W.

BULLETIN OF THE AMERICAN GEOGRAPHICAL SOCIETY.

NO. 3, 1886. Florida and the West Indies. Over the Mexican plateau in a diligence. Geographical Notes.

NO. 4, 1886. Some of the geographical features of South-eastern Alaska. The origin of the name America. On the extermination of the great Northern sea-cow (*Rytina*). Ancient habitations of the Southwest. Geographical Notes.

NO. 5, 1886. Table of contents, etc., for Vol. XVIII. Transactions of the Society for the year 1886.

NO. 1, 1887. Oceanic Islands: their physical and biological relations. New Mexico: its geography, scenes, and peoples. Stone-Pasha's work in geography. Geographical Notes.

NO. 2, 1887. The great walled river. Recent explorations in Egypt. Colonel Chaillé-Long on the Juba. Geographical Notes. Obituary: Vice-President Roswell S. Hitchcock, D. D.

J. H. G.

ENGINEER.

APRIL 15, 1887. Compound versus triple expansion marine engines.

The same engine was worked alternately as compound and triple expansion, and the conclusion deduced that more I. H. P. per pound of coal was obtained in the latter case, but more knots per ton of coal in the former.

The Italian ship Dogali had her official trial trip, and is the fastest cruiser afloat. The mean speed over the measured mile was 19.66 knots; I. H. P. 7600; revolutions, 154.

W. F. W.

ENGINEERING.

FEBRUARY 25, 1887. Torpedoes and war ships.

APRIL 1. Torpedo boat trials (from Proceedings of Institute of Naval Architects).

Results of trials to determine the value of m in the formula $v = m \sqrt[3]{\frac{\text{I. H. P.}}{B^2}}$ (the usual formula employed in France). $B =$ area of midship section and m a coefficient of efficiency. The value of m was found to increase up to 11 knots, attain a minimum at 17 knots, and to increase slightly at higher speeds.

Paper on the twin-screw torpedo boats Wiborg and El Destruidor (from Proceedings of Institute of Naval Architects).

Valuable paper on scientific iron founding, with special reference to mechanical character and chemical composition.

APRIL 8. On the corrosion of iron and steel ships.

With the aid of a galvanometer it was found that rust is quite as capable of setting up galvanic action as the magnetic oxide, even if the action be less intense.

Liquid fuel experiments.

A trial of a new furnace invented by Lieutenant Pashinin and used on a river steamer in Russia, showed that 1 pound of petroleum refuse evaporated 15.6 pounds of water, or 2¼ times as much as 1 pound of coal.

Paper on fuel supply in ships of war.

APRIL 15. Comparative effects of belted and internal protection upon other elements of design of a cruiser (from Proceedings of Institute of Naval Architects).

Last week the trials of H. M. S. Anson were made with 94 pounds of steam and 97 revolutions; the I. H. P. was 8320 and speed 16½ knots; consumption of coal 2.3 pounds per I. H. P. With both screws working ahead the port half circle was turned in 2 minutes 28 seconds; the complete circle, 640 yards diameter, was turned in 5 minutes 15 seconds. The starboard half circle was turned in 2 minutes 46 seconds, and the complete circle, 650 yards diameter, in 5 minutes 47 seconds. On the forced draught trials the steam pressure was 101 pounds; revolutions 108.6 port, 108.9 starboard; I. H. P., 12,568; consumption of coal 2.2 pounds per I. H. P.; speed, 17.4 knots.

On high-speed twin screws (from Proceedings of Institute of Naval Architects), with following table:

Particulars of Some Recent High-Speed Twin Screws.

SHIP.		A.	B.	C.	D.	E.
Length in feet		325	315	300	220	250
Breadth		68	61	46	34	32½
Draught on trial	Forward	26′ 2″	24′ 6″	15′ 6″	12′ 10″	13′ 1″
	Aft	27′ 3″	25′ 6″	19′ 9″	15′ 2″	14′ 7″
Displacement in tons		9690	7645	3584	1560	1544
I. M. S., square feet		1560	1287	744	438	392
Speed of ship, knots		16.92	17.21	18.18	16.91	17
I. H. P.		11,610	10,180	6160	3115	3045
Revolutions per minute		107.2	88	122.6	150.4	132.1
Pitch of screw		19′ 5″	22′	17′ 6″	12′ 7½″	14′ 9″
Slip, per cent		17.6	10	14.2	9.7	11′ 4″
Diameter of screw		15′ 6″	18′	13′	10′ 6″	11′
Diameter of boss		4′ 4″	4′ 11″	3′ 5″	2′ 9″	2′ 10″
Number of blades		4	4	3	3	3
Blade area of one screw		72	87	47	24	24
$\frac{\text{Pitch}}{\text{Diameter}}$		1.25	1.22	1.34	1.2	1.34
$\frac{\text{Disc}}{\text{Blade area}}$		2.62	2.92	2.82	3.6	3.96
Immersion of screw		9′	5′ 3″	4′ 4″	2′ 9″	1′ 10″

APRIL 29. Twin-screw torpedo boat (illustrated).

This boat is one of two built for the Italian Government by Yarrow & Co. Its length is 140 feet; beam, 14 feet; displacement, 100 tons; mean of six runs on measured mile in rough weather, 25.1 knots; revolutions, 274½; steam, 130.

The belted cruiser Orlando.

Her length is 300 feet; beam, 56; displacement, 5000 tons; draught forward, 20 feet, aft, 22 feet. The trial was for four hours with forced draught of 1¼ inches and the vessel loaded down to water line. Steam pressure, 129 pounds. Total I. H. P. 8622. The helm was put hard over (70°) in thirty seconds, and the circle, 480 yards, was made in three minutes, the shortest time in which it has ever been done by a vessel of her length. On the measured mile a mean speed of over 19¼ knots was attained, the highest ever attained by a British armed vessel.

A fast torpedo boat.

This boat, built by Thorneycroft & Co. for the Spanish Navy, attained a mean speed of 26.1 knots on a recent trial. Her length is 147 feet 6 inches; beam, 14 feet 6 inches; draught, 4 feet 9 inches.

Triple-expansion engines.

A comparison of the results of the working of eleven compound and nine triple-expansion engines showed a gain in economy of about 25 per cent in favor of the latter. W. F. W.

JOURNAL DU MATELOT.

APRIL 24. Interesting account of the use of oil in a violent storm, by the steamer Dragut.

MAY 29. Means for preventing collisions, a system of sound signals, by Captain Frémont, of Havre, France. D. H. M.

MECHANICAL ENGINEER.

FEBRUARY 26. Account of the testing and breaking of one of the steel shafts made for the U. S. S. Boston.

MARCH 26. Article on modern high-speed marine engines, giving a number of details.

MAY 7. Cost of electric lighting of vessels (from report of P.-A. Engr. G. W. Baird, U. S. N.).

The expenditures for one year were as follows:

14¾ tons of coal, at $5.17 per ton	$76 25
43½ gallons of oil, at 55 cents per gallon	23 92
149 lamps, at 35 cents	126 25
34 3-light safety plugs, 18 of 6 lights, 1 of 30 lights	4 24
2 key sockets, 4 plain sockets	3 80
3 wire shade holders, at 30 cents	90
3 pounds copper wire, at 40 cents	1 20
2 pounds insulation tape, at 50 cents	1 00
1½ gross assorted screws, at $1.25	1 87
46 feet flexible cord, at 15 cents	6 90
4 attachment plugs, at 40 cents	1 60
3 dynamo brushes, at 60 cents	1 80
1 standard, at 44 cents	44
Total	$249 98

The dynamo was in operation 1574 hours 26 minutes, and during that time a mean of 47 lamps were in circuit. The cost of the light was .042 cent per candle power per hour. The mean life of a lamp in the engine room was 932 hours 54 minutes. These lamps were in circuit all the time, and were lighted and extinguished by the starting and stopping of the dynamo.

The forced draught system on the U. S. S. Alliance.

The system was devised by the Bureau of Steam Engineering, and by it the I. H. P. per square foot of grate was increased from 4.02 to 12.38. The ash pan doors are closed instead of the stoke hole.

Test of steel screw blades for the U. S. naval cruisers (made by P.-A. Engr. C. R. Roelker, U. S. N.).

The strain put upon the blades was in each case 2.3 times the maximum which would occur with the blade in use. The deflection was remarkably uniform, and increased gradually from root to tip.

W. F. W.

RAILROAD AND ENGINEERING JOURNAL.

MAY. Ribbed boiler tubes.

These tubes have longitudinal internal ribs, invented by M. Chomienne, and are manufactured in France by "La Societé Industrielle et Commerciale des Métaux." It is said they can be made almost as cheaply as smooth tubes, and are just as easy to sweep with the tube brush. Comparative trials of smooth tubes and ribbed ones in the boilers of a steamer on the Rhone, showed in one case a saving of 35 per cent, and in another case a saving of 24 per cent by the use of the latter tubes. By changing from smooth to ribbed tubes in one case, the heating surface was doubled and the calorimeter reduced only one-fifteenth.

JUNE. Large steel castings.

The Standard Steel Casting Co., of Thurlow, Pa., recently turned out and shipped to Philadelphia, a steel stem casting weighing 15,000 pounds for a gunboat building by Cramp & Sons, and a stern casting weighing 13,000 pounds, the first of cast steel ever made in the United States. Also sixteen cast-steel propeller blades for the Chicago, Boston, and Atlanta. The weight of each blade for the former ship was 2410 pounds, and for the two latter ships 3750 pounds.

W. F. W.

REPORT ON EXPERIMENTAL FIRING AT THE CAST STEEL FOUNDRY OF FRIEDRICH KRUPP, AT THE PROVING GROUNDS AT ESSEN AND MEPPEN.

No. 67, 1887. Tests of experimental firing with 8.4-cm. rapid-firing ship's guns L/27.

The gun itself remains as previously described, excepting a change in the chamber to suit the new combined cartridge and shot. The carriage has been considerably modified, the lower pyramidal carriage resting on balls, on which it trains. The recoil of the upper carriage is taken up by hydraulic cylinders. The gun is elevated by an endless screw working into a toothed arc. The training is effected by a similar arrangement. Weight of projectile 7 kg.; charge, 1.6 to 1.7 kg.; cubical powder (?) of 10 mm.; initial velocity, 470–480 m. With a trial powder the initial velocity vas increased to 506 m. It takes three men to work the gun; one man sits on the seat and sights the gun. He has the firing string attached to a belt around his body. He fires by throwing his body

back. Rapidity of fire, 10 shots in 34 seconds, or at the rate of 18 shots a minute. They were fired at the bow of a torpedo boat, distant 400 metres. The middle fore and aft line of the bow was in the line of fire, and the bow plates stood at 15° to each other and perpendicular on the ground. The steel plates had strength of 5 m. All the shot hit, as will be seen on diagram. Later 7 shots were fired in 19 seconds, or at the rate of 22 per minute. Therefore, in one minute $7 \times 22 = 154$ kg. weight of shot can be fired with $80{,}000 \times 22 = 1{,}760{,}000$ m. kg., *vis-viva*. This is the best result yet obtained by rapid-firing guns.
E. H. C. L.

REVUE DU CERCLE MILITAIRE.

No. 12, March 20, 1887. Military forces of Canada.

No. 13, March 27. Torpedoes and torpedo boats. The French fleet, January 1, 1887. New infantry equipment in Germany.

No. 16, April 17. New equipment for French infantry.

No. 17, April 24. Trials with the Maxim revolving guns. Experiments with new repeating rifle at Vienna, Austria.

No. 19, May 8. Launch of Austrian turret vessel, Princess Stefanie, at Trieste, giving general description, armament, lighting, and machinery.

No. 23, June 3. New equipments for German infantry, giving several different views.
D. H. M.

REVUE MARITIME ET COLONIALE.

May. Instrument for self-registering the rolling of a ship. The Legion of Honor (continued). Study on the combined operations of fleets and armies, commencement of Volume V., Volumes I., II., III. and IV. having been published in 1882–'83. Austrian expedition to the Island Jan-Mayen (continued). Observations made at New Foundland on board the frigate La Clorinde during the cruise of 1886.

June. Continuation of the combined operations by sea and land. Under the head of "Chronique," or selections from other papers, is an article from the Marine Engineers, describing an apparatus intended to signal the position of the helm to an approaching vessel. This position can be shown either at day or at night. (See Professional Notes, present number.)
D. H. M.

RIVISTA MARITTIMA.

February.

The French Minister of Marine has issued a circular, from which the following is extracted with regard to the care of the boilers of torpedo boats. Upon lighting fires the blowers are not to be used, but natural draught is to be depended upon. The fires are not to be urged, but to be regulated in such manner that a steam pressure will begin to show after one and three-quarter hours. Allowing ten or fifteen minutes for the pressure to rise to five or six kilos, it will be two hours from the time of lighting fires before the torpedo boat is ready to move. The blowers will not be started until the torpedo boat is in motion, and then only gradually. When the torpedo boat is in motion, except in case of absolute necessity, of which the commanding officer is to be the sole judge, all sudden changes of speed are to be avoided, and especially all sudden stops when the engine is working full power. Changes of speed both of the engine and of the blowers should be made gradually and progressively. The doors of the boiler compartments should never be entirely opened or shut at once, but gradually. When the fires are to be hauled, the steam pressure should be allowed to fall some time before the engine is stopped, and at the same time slow down the blowers gradually, aiming to stop them just as the engine stops. The steam pressure may be relieved either through the safety valves or the bleeding valve to the condenser. If, when the engine is stopped, the fires are heavy, they may be partly hauled by taking out a few of the grate bars. If, on the other hand, they are not too heavy, they may be left as they are. The furnace and ash-pit are then to be shut air-tight, the cover put on the smoke-pipe and on the air-pipe from the blowers, and then, or at least on the following day, the boiler compartment is to be shut and left to cool down gradually.

The Minister of Marine has proposed a reorganization of the corps of the Navy, the most important change being in the Engineer Corps (Ufficiali Meccanici), who were to be completely assimilated (in rank—W. F. W.) to the line officers, the highest to have the rank of fleet captain (Capitano di Vascello). The parliamentary committee, to whom the proposed law was referred, did not favor the changes, and especially that relating to the status of the engineers. W. F. W.

TRANSACTIONS OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

VOL. VIII. The new calorimeter.

Paper giving tabulated results of boiler tests made with a new calorimeter. This instrument works on an entirely different plan from any other. The principle of operation is to evaporate the moisture held by the steam, and measure its quantity by determining the amount of heat required for this purpose. The instrument is described at length in Vol. VII., p. 178, of the Transactions.

Capital's need for high-priced labor.

The paper and following discussion treat of the wage question at length and in detail. The conclusion is reached that, "as a general rule, large wages return many times as much value to the shops as low wages." Also it is better to pay each laborer in proportion to what he does than to pay the same wages to all engaged in the same class of work. W. F. W.

UNITED SERVICE GAZETTE.

MARCH 26. Convoys; are they any longer possible?—discussion on.

APRIL 2. Belligerent rights; and what is lawful in war time—discussion on. A new gun for the Royal Navy, Armstrong, is a 30-pounder, weight with carriage 92 cwt.—intended for repelling torpedo attacks. Carriage fitted with Vavasseur's patent automatic machinery. Muzzle velocity 1900 feet.

APRIL 16. Improvements in camp kitchens, field cooking, camp equipage, and military transport. Trial of a new plate made by Cammell & Co.; no shells penetrating, the steel shells being completely broken up.

MAY 14. Launch of the Sans Pareil at Blackwall.

Dimensions: Length, 340 feet; breadth, 70 feet; depth, 37 feet 6 inches; displacement, 10,470 tons; engines, 7500 to 12,000 H. P. Armament, two 16-inch 111-ton guns, twelve 6-inch 5-tons, nine 3-pounder quick-fire, one 10-inch 29-ton gun, twelve 6-pounder quick-fire, two 1-inch Nordenfeldt, eight 14-inch Whitehead torpedo tubes, and four 0.45-inch Nordenfeldt. The Sans Pareil has eighteen inches steel-faced armor.

Launch of the new composite sloop Buzzard.

Length, 195 feet; breadth, 30 feet; draught, 12 feet 2 inches; displacement, 1075 tons; 2000 H. P. Armament, eight 5-inch B. L. guns. Unarmored, but vital parts are protected by a steel deck running the whole length of ship.

MAY 21. An article on torpedo boats.

JUNE 11. Launch of the Immortalité at Chatham.

A twin-screw belted cruiser 300 feet long, 56 feet wide; draught forward, 19 feet 6 inches; aft, 22 feet 6 inches; displacement, 5000 tons; I. H. P., 8500; speed, 18 knots. Principal battery, two 9.2-inch B. L. and ten 6-inch B. L. Steel-faced belt ten inches thick, and iron plating at end of belting sixteen inches thick.

JUNE 18. Blockades under existing conditions of warfare. The second torpedo attack upon the Resistance. D. H. M.

LE YACHT.

MARCH 12. P. 84: Submarine boats. P. 90: Turnabouts, description and plans of these little vessels, French and English. P. 91: The new cruisers building in France.

MARCH 19. P. 95: The French manœuvres of 1887; a criticism on the orders given for the contests between the fleets and torpedo boats. P. 98: Hill and Clark's boat detaching apparatus, drawings and description. P. 101: El Destructor, giving dimensions, etc.; also, some of the chief faults in her construction.

APRIL 2. P. 115: The Nice, French cruiser for cadets. P. 116: Trial of the Camperdown's engines. View and description of the rudder of the Spanish torpedo boat (cruiser) El Destructor.

APRIL 9. P. 119: Torpedo boats and Mère Gigogne.

The Mère Gigogne is thus described: She will be designed to carry six torpedo boats; will be an armored vessel, with 35-cm. plates, armed with two 34-cm. guns; also, repeating cannon and rapid fire guns. She must have great speed. Plans for such a vessel have been advertised for, and she will probably cost over twelve million francs.

P. 122: English sea-going torpedo boats.

This article mentions the Rattlesnake, Grasshopper, Spider, and Sandfly, giving dimensions, armament, and trials of speed of Rattlesnake.

APRIL 16. P. 131: Description of Mr. Trouve's electric engines for small boats, showing plans of battery; arrangement for electric ventilator and fog horn and electric boat lights.

APRIL 30. P. 145: Plan and description of apparatus for pouring oil on the sea from ships. P. 147: Manœuvres of torpedo boats in Mediterranean. System of protection against torpedo boats.

MAY 7. P. 155: Description and view of torpedo boat Ouragan. P. 156: Manœuvres of torpedo boats. Launch and description of the Neptune. Trial of cruising battery Sfax at Brest.

MAY 14. Before the manœuvres; referring to the operations about to be carried on by the French between a fleet of ironclads and a fleet of torpedo boats. P. 163: Trials of a new style of gunboat.

MAY 21. P. 171: Protection of fighting ships and Melinite projectiles. P. 173: Accidents at sea, and means for preventing them.

MAY 28. P. 181: Fog signals. P. 185: Launch and description of French iron-clad Marceau. The iron-clad barbette vessels of the English Navy. P. 186: The English torpedo flotilla.

JUNE 4. P. 199: Recent auto-mobile torpedoes.

JUNE 11. P. 211: Description and chart of the canal from the North Sea to the Baltic.

This canal was inaugurated June 3, 1887, by the Emperor of Germany.

End of article on recent auto-mobile torpedoes. D. H. M.

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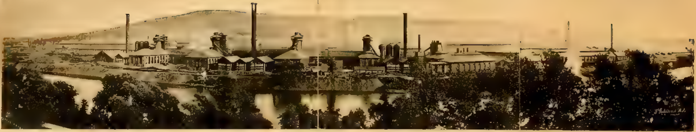

WORKS OF THE BETHLEHEM IRON COMPANY,

SOUTH BETHLEHEM, PA.

1889.

THE PROCEEDINGS

OF THE

UNITED STATES NAVAL INSTITUTE.

Vol. XV., No. 4. **1889.** **Whole No. 51.**

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

DESCRIPTION OF THE WORKS OF THE BETHLEHEM IRON COMPANY.

BY W. H. JAQUES (late United States Navy),

M. I. and S. Inst., M. Inst. M. E., Assoc. Inst. C. E., Assoc. I. N. A., late Secretary United States Gun Foundry Board, late Secretary Senate Ordnance Committee, Member of Institute.

Less than three years ago The Bethlehem Iron Company broke ground to carry out the writer's proposition for the introduction and erection of complete hydraulic forging machinery for the manufacture of the largest guns and the heaviest shafting and armor plates; to erect a plant long needed in the United States, to make the country independent in the possession of the means of supplying the nation with the most powerful guns and of equipping her ships with the most efficient shafting and armor.

The company that undertook this great work was conceived as early as the year 1857, when the senior partner of the firm of A. Wolle & Co., of Bethlehem, procured a charter, dated April 8, 1857, for a company styled "The Saucona Iron Company."

By an Act of Legislature, dated March 31, 1859, the corporate title of the company was changed into that of "The Bethlehem

Rolling Mills and Iron Company," and the services of John Fritz, of Johnstown, Cambria County, Pennsylvania, were secured to superintend the construction of the works and the subsequent manufacture and production.

Its first Board of Directors, chosen June 14, 1860, was composed as follows: President, Alfred Hunt, of Philadelphia. Directors, Augustus Wolle, of Bethlehem; Asa Packer, of Mauch Chunk; John Knecht, of Shimersville; John Taylor Johnston, of Central Railroad of New Jersey; Charles B. Daniel, of Bethlehem; Charles W. Rauch, of Bethlehem; Secretary and Treasurer, Charles B. Daniel.

The present Board consists of John Knecht, of Shimersville; Rob't H. Sayre, of South Bethlehem; Joseph Wharton, of Philadelphia; E. P. Wilbur, of South Bethlehem; W. W. Thurston, of South Bethlehem; Rob't P. Linderman, of South Bethlehem; George H. Myers, of South Bethlehem. The officers are: President, W. W. Thurston; Vice-President, Rob't P. Linderman; General Manager, Rob't H. Sayre; Chief Engineer and General Superintendent, John Fritz; Assistant Superintendent, R. W. Davenport; Secretary, Abraham S. Schropp; Treasurer, C. O. Brunner.

These works are situated at South Bethlehem, Northampton County, Penna., on the Lehigh river, 87 miles from New York by way of the Lehigh Valley Railroad and Central Railroad of New Jersey, and 55 miles from Philadelphia via the North Pennsylvania Branch of the Philadelphia and Reading Railroad. They are connected with the anthracite coal regions by the Lehigh Valley and other railroads, various roads and their connections affording ample facilities for the cheap transportation of fuel and ores to the works, and convenient outlets for the distribution of the varied products.

At the present time the works consist of offices, boiler houses, blast furnaces, puddle mill, merchant steel mill, Bessemer department, department of construction and repairs, ordnance and armor plate department, laboratories, mines, quarries, etc.

The buildings have been erected from designs made here. They are of hard gray sandstone from adjacent quarries, and brick, and the roofs, covering about 18 acres, are of slate from the vicinity.

OFFICES.

The offices are roomy, well lighted, and equipped with modern appliances and well-lighted drafting rooms.

BOILER HOUSES.

The boiler houses are detached, and conveniently arranged for the delivery of fuel, and the boiler settings peculiar, to provide for expansion in any direction without subjecting the boilers to any injurious strains.

BLAST FURNACES.

No. 1 furnace was commenced in 1860 and completed and put in blast in January of 1863; No. 2 was completed in 1867; in 1868 the furnace of the Northampton Iron Company was purchased and put in blast during December of that year under the name of No. 3, and after running 16 years was dismantled; furnaces Nos. 4 and 5 were put in blast in March, 1876, and March, 1877, respectively; furnace No. 6 was completed in 1883; furnace No. 7, purchased in 1879, is situated at Bingen, on the Philadelphia and Reading Railroad, about six miles from Bethlehem.

Furnace.	Height.	Bosh.	Hearth.	
			Feet.	In.
No. 1	61	15½	8	6
" 2	70	16	10	0
" 4	70	16	10	0
" 5	70	16	10	0
" 6	70	19	10	0
" 7	65	16	10	0

These furnaces are widely known for their excellent Bessemer iron. The fuel used in smelting is anthracite coal from the upper Lehigh region, with a mixture of Connellsville coke. A choice variety of hematite and magnetic ores from the most celebrated mines at home and abroad allows of an excellent pig for making Bessemer and open-hearth steels of a very superior quality. A railway connects the furnaces with the converters for the transportation of fluid metal, thus permitting the making of Bessemer steel by the direct process. The total annual capacity is 160,000 tons.

The engine house, separated from the furnaces by the stock house, is a massive stone building 60 × 327 feet, erected with the special view of protecting the blowing machinery from the dust and dirt of the furnaces. It contains seven horizontal blowing engines, five of which are compound; steam cylinders, high pressure, 30 inches diameter, low pressure, 54 inches diameter, 80 inches stroke; blowing cylinder, 80 × 80 inches. The other two engines are single condensing; steam cylinder, 54 × 80 inches, blowing cylinder, 80 × 80 inches.

The blowing engines of the horizontal compound type work at a high speed and under high pressure of blast with a degree of smoothness and noiselessness that is rarely observed in a blowing engine. A strong feature in these engines, and one now generally recognized by blast-furnace engineers, is their capacity of blowing as high a pressure as 20 pounds of air, this pressure sometimes being necessary to save the furnace and obviate expensive delays.

The cast house of each furnace is at a right angle and forms a wing to the stock house. The spaces intervening between the cast houses are used for cinder yards on one side, while on the other are located the boilers and hot-blast stoves.

The newest furnaces are provided, each with three Whitwell fire-brick regenerative stoves, which give excellent economical results. These stoves are 20 feet exterior diameter and 60 feet high.

The stock house is common to all the furnaces, and is a continuous building running parallel with the line of furnaces and to their full extent. It is 61 feet wide. A double track runs the length of the building on trestles 12 feet above the floor level. The floor is divided off into spaces on each side, and a central aisle renders all parts accessible.

THE PUDDLE MILL.

This mill contains three double double, four double, and one single puddling furnace, with boilers over furnaces. It was originally built for the production of iron rails, and since they have no longer been in use, has been noted for the high quality of merchant iron and muck-bar produced. The mill has recently been used for the production of muck-bar exceedingly low in phosphorus, which is used for remelting at the open-hearth furnaces for the production of the high quality of steel necessary for ordnance and shafting work.

MERCHANT-STEEL MILL.

The merchant-steel mill is principally used for the rolling of smaller sections of rails, and special grades of Bessemer steel into billets, which are sold to manufacturers for the production of merchant bar, wire rods, axles, etc. The rolling of iron shapes, principally used for construction in the works, is an important product of this mill.

BESSEMER DEPARTMENT.

Steel Mill.—This mill is a large and massive stone structure, having numerous and uniform arched openings in its sides, and an iron and slate roof with a continuous lantern. The total length of the nave is 1512 feet, and its width is 111 feet. The transepts are also 111 feet wide, and their total length, including the crossing of the nave, is 386 feet. The clear height is 29 feet. This building runs longitudinally east and west, parallel with the Lehigh Valley Railroad. In the western or upper portion of the mill is located the converting department, consisting of four 7-ton vessels. These vessels are arranged in a straight line across the mill, an iron platform supported on cast-iron columns surrounding them. Back of the vessels stand the iron and spiegel cupolas; they are supplied with double platforms, one above the other, commonly called the charging and tapping floors. These floors communicate with the vessel platform and with each other by means of iron stairs. Three vessels are worked alternately, while one is off for repairs; the iron cupolas are run four on and four off; the spiegel cupolas are run two on and two off. This method of working facilitates repairs and prevents the necessity of any excessive repairing or protracted delays. The vessels are wrought-iron shells, eight feet in diameter; the body is completely lined with natural stones of mica schist, roughly hewn to shape, and the nose is lined with fire-brick. A vast number of experiments were tried before a natural stone could be found that would not either flake off under the heat of glazing or become rapidly denuded. The excellence of this stone depends upon its mechanical structure, which of course is a thing hardly capable of description. Excepting some not expensive repairs to the nose, one of these linings is good for 30,000 tons of ingots. In the old plant, 54,000 tons were made on the linings of the two vessels without the removal of any stones excepting in the nose and a few at the bottom joint. The vessel bottoms have 17 fire-brick tuyers, with 12 holes, three-eighths inch each. Between the tuyers are set on end bricks like the blast-furnace lining brick, as near together as they will stand. The small space left between the bricks and tuyers is rammed with ordinary gannister bottom stuff, and so small is the total quantity of water in the bottom that it needs oven-drying only four hours; the bottoms stand 12 to 14 heats quite uniformly. The output of the converting department averages 4000 tons of ingots per week of eleven shifts; the plant has been worked at a higher rate of production. The annual capacity is 225,000 tons. The heats of ingots run from seven to eight tons according to the weight of rail. Fourteen-inch ingots are bloomed down to seven inches square, and cut into single and double rail blooms for the rail mill. The stock ladles, molten metal, ingots, etc., are moved by a system of narrow-gauge tracks. This system, by means of frequent turn-tables, switches and hydraulic lifts, offers a complete and convenient conveyance. The casting pits and handling floor are under complete command, with a systematic arrangement of hydraulic cranes.

The blowing machinery is located in the upper transept, next the railroad. There are two Bessemer blowing engines of the following dimensions: The smaller has two steam cylinders 36 × 60 inches, coupled direct with two blowing tubs 48 × 60 inches. The blowing tubs are placed back of the steam cylinders and on the same bed-plate; the steam cylinders are coupled on their forward end through cross-heads and connecting rods to a fly-wheel shaft, whose cranks stand at right angles. The larger engine has two steam cylinders 56 × 66 inches, and two blowing tubs 60 × 66 inches arranged like the smaller. The smaller was the original engine, but, proving inadequate to the demands of the increased plant, it has been replaced by one more powerful, and is now used as a reserve or emergency engine. The large blowing engine running with 50 pounds of steam is capable of maintaining a blast pressure of 40 pounds of air. The cupola blast is obtained from four No. 7½ Baker blowers, coupled direct to the shaft of a compound engine running 90 revolutions.

The blast pressure at the blowers is about 1¼ pounds, and twelve ounces at the tuyers. Another compound engine directly coupled with four blowing tubs is kept in reserve for the cupolas.

A Worthington duplex and two Worthington compound duplex pumps are also located in this transept, and supply a water pressure of 300 pounds to the square inch for the operation of cranes, hoists, etc.

In the opposite transept are two Pernot furnaces, with their accompaniments. Just outside this transept is the ladle-house, supplied with a number of short tracks and turn-tables. The freshly lined ladles are placed on cars and run into position on these tracks; when in position a cap is lowered, forming a combustion chamber of the ladle, and a stream of gas and air, in regulated proportions, admitted through the center of the cap, causes more rapid drying and hotter ladles than could be obtained by the old method of building fires in them. The number of ladles required is considerably reduced by this method.

The vessel-bottom repair shop is located in the upper end of the mill, and is furnished with hydraulic cranes for handling and ovens for drying.

At this end of the mill a brick foundry has been erected on the south side and adjoins the mill. This foundry is used for the manufacture of ingot moulds, the consumption being 6 to 8 per day. The equipment consists of a cupola and two power cranes.

In the main portion of the mill, just below the pits and handling floor, are six Siemens reheating furnaces. Three furnaces are placed on each side, with hydraulic cranes for charging and drawing the ingots. Centrally, between these furnaces and under command of the hydraulic cranes, run two narrow-gauge tracks, one running to the casting pits, the other to the blooming train. There are two blooming mills, two engines, and three sets of rolls. The smaller engine is 36 by 60 inches, coupled direct to two sets of three high 32-inch rolls. Both sets are supplied with tables operated by power and controlled by two levers at one point. The large mill is also three high; the rolls are 48 inches diameter and 10 feet long; the engine is 65 inches by 8 feet, with 90-ton fly-wheel; this mill is similar to the smaller, but handles a larger ingot. From the blooming mill the ingot passes to steam hammers, is cut into rail-blooms, and charged into the rail-mill heating furnaces.

These furnaces (four in number) are similar in construction to the blooming mill furnaces, varying only in size, and are located immediately below the blooming mill. The rail mill consists of three sets of rolls; the engine is an upright compound, 36-inch high pressure, and 56-inch low pressure cylinders, 50-inch stroke; the rolls are 24 inches, three high. The rail passes from the rolls to the hot saws and thence to automatic hot straighteners, hot beds, cold straighteners, drill presses, and then to a line of driven rollers, which carry the rails to the cars for shipment.

A new 28-inch mill rolls heavy sections and long lengths. This train is driven by three high-speed compound engines on one shaft, connected with the middle roll and driving direct. The aggregate power of these engines is 8000 horses. The necessary tables are of novel design and are worked automatically by water or air.

In the heating furnaces of this department, a gas made from crude petroleum oil is used for fuel at the present time, instead of coal gas made in Siemens producers, as was originally the case.

DEPARTMENT OF CONSTRUCTION AND REPAIRS.

This department includes pattern, foundry, machine and smith shops, for construction purposes and the necessary repairs.

The *Machine Shop* is a stone structure 253 by 64 feet, containing lathes, planers, boring mills, gear cutter, drill presses, shapers, slotting and straightening machines, and pipe cutters, among which are the 120-inch planer, a 16-foot boring mill, three heavy lathes and two large universal drills—one having a span of 14 feet.

The *Foundry*, also of stone, is 107 feet by 64 feet, and forms an L with the machine shop. It is supplied with two cupolas and three powerful cranes, and is thoroughly equipped for all the necessary work.

ORDNANCE AND ARMOR-PLATE DEPARTMENT.

This department, now in operation, when completed, will comprise gas producers, open-hearth furnaces, fluid compression apparatus, soaking pits, hydraulic forging presses, plate rolling mill, crucible furnaces, hydraulic and pneumatic cranes, a 125-ton single-acting steam hammer, bending press, oil-treating and annealing shops, and machine shop.

The *Open-Hearth Furnaces* will have a capacity for casting ingots of 100 tons.

The *Hydraulic Forging Presses* will produce the largest forgings required for ships of any tonnage thus far designed, and for guns of the largest caliber now in existence. A specialty will be made of hollow forgings of large dimensions.

The *Plate Rolling Mill* will be capable of supplying all probable demands for rolled plates of every description.

The *Pneumatic and Hydraulic Cranes* have a capacity of from 25 to 150 tons.

The building containing the open-hearth furnaces, forging presses, fluid compression apparatus, and plate mill is 1155 feet long by 111 feet wide, with transept and annexes for engines, gas producers, etc.

The *Oil-treating and Annealing Shops* are conveniently arranged for economical treatment of heavy gun and other forgings, and of armor plates.

The *Machine Shop* contains lathes, planers, boring mills, slotters, drilling machines, shapers, etc. Among these are: a planer in which 13 feet by 13 feet by 50 feet 10 inches can be planed; 10-foot face-plate lathe; boring mills of the most recent design, and some of the most powerful lathes in existence. The building is 641 feet in length by 116 feet in width.

The traveling cranes are of the pneumatic type, 60 feet span, and from 25 to 100 tons capacity.

The shops are well lighted by electricity, and the entire plant supplied with efficient rail communication and adequate rolling stock.

The casting and forging presses were manufactured by Sir Joseph Whitworth & Co., of Manchester, England, and designed by Mr. Gledhill, Managing Director of that firm; the heavy tools were constructed from designs by Mr. Gledhill and Mr. Fritz; and all erected under the latter's direction.

In the designing and erection of the hammer plant for making armor plates, the plans of Schneider & Co., of Creusot, France, were consulted and followed as far as they met the conditions of construction already adopted.

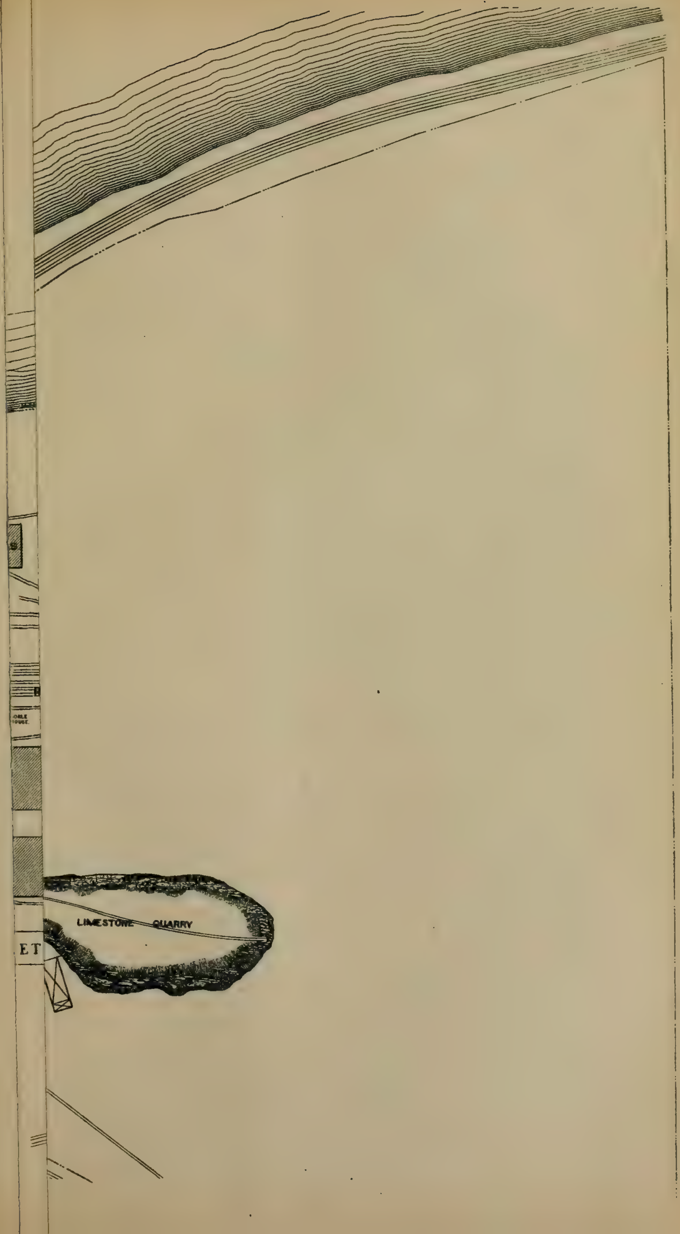
This department, for the production of heavy forgings for guns, armor, shafting, and other purposes, is rapidly approaching completion, and within a year will equal, if not surpass, any other establishment of its kind in the world in its capacity to supply war material, and the perfectness of its means of rapidly producing the heavy forgings required for modern high-power ordnance and the most powerful armored ships yet designed. With a casting capacity for ingots of 100 tons, fluid compression plant, a steam hammer of 125 tons (falling weight), the most powerful hydraulic forging presses ever constructed, and tools of the most approved and advanced type for shaping and finishing, this company has already manufactured and delivered all of the heavy shafting of the cruisers Philadelphia, San Francisco, and Newark, together with forgings for 4-inch, 6-inch, 8-inch, and 10-inch breech-loading rifles, and is now engaged upon the shafting of the armored coast-defense vessel Maine, and 8-inch, 10-inch, and 12-inch breech-loading rifles for both the army and navy, and the armor of the barbette battleship Puritan, the double-turreted monitors Amphitrite, Monadnock, and Terror, the battleship Texas, and the armored cruiser Maine.

In addition to the war material (including hollow and other forgings for shafting, guns, armor, shields, and conning towers), special and miscellaneous forgings, the works have an output of some 250,000 tons of rails, blooms, and billets, and miscellaneous work, under a personnel of about 3000.

The *Chemical and Physical Laboratories* are very complete, and contain Riehle and Emery testing machines of 100,000 and 300,000 pounds capacity.

The company's property at South Bethlehem covers an extent of about 1¼ miles in length by ¼ of a mile in width, of which about 18 acres are under cover.

BETHLEHEM, PA., *October*, 1889.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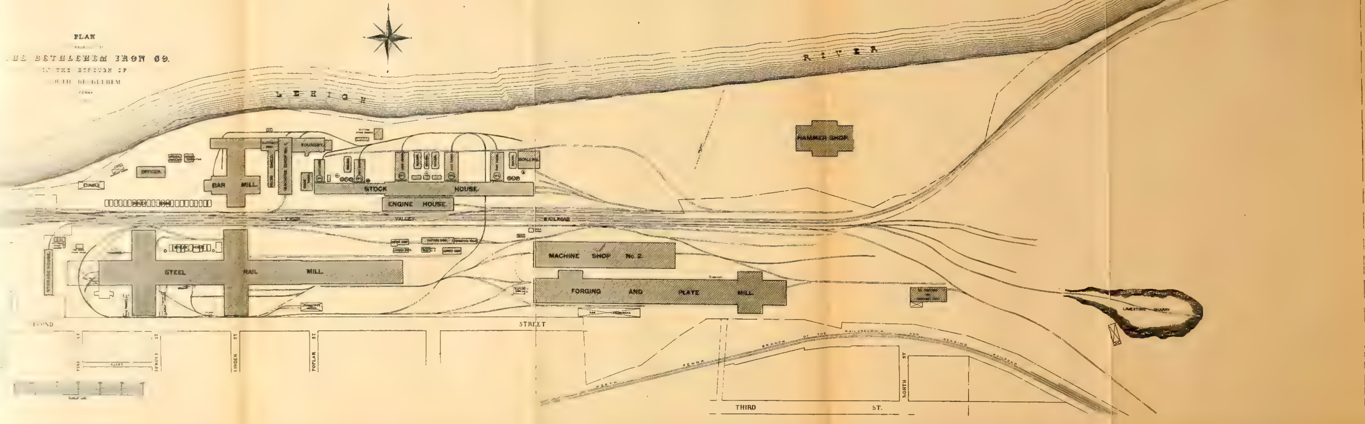
PLAN
THE BETHLEHEM IRON CO.
IN THE BOROUGH OF
SOUTH BETHLEHEM
PENNA.
LEHIGH
RIVER
STABLE
OFFICES
BAR MILL
FOUNDRY
STOCK HOUSE
ENGINE HOUSE
BOILERS
HAMMER SHOP
LEHIGH VALLEY RAILROAD
STORAGE HOUSE
STEEL RAIL MILL
MACHINE SHOP No. 2
FORGING AND PLATE MILL
LIMESTONE QUARRY
NORTH PENNA BRANCH OF THE PHILADELPHIA AND READING RAILROAD
POND
STREET
PINE ST
ALLEY
SPRUCE ST
LINDEN ST
POPLAR ST
THIRD ST.
NORTH ST

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

OUR FUTURE NAVY.

By Rear-Admiral S. B. Luce, U. S. Navy.

[Reprinted from the *North American Review.*]

In his "Essay on History," Lord Macaulay observes that "no past event has any intrinsic importance; the knowledge of it is valuable only as it leads us to form just calculations with respect to the future." Agreeably to that precept, a retrospective survey, so appropriate in this centennial year, will enable us to form just calculations as to what may be reasonably anticipated in respect to the development of our new navy. A necessary condition of the forecast is that no violent political eruptions or international complications shall disturb the course hitherto followed by legislation on naval affairs.

Before proceeding further, let us inquire what constitutes a navy. A navy is, in one sense, a sea army. Or, to speak more correctly, its principal constituent, a fleet, is a sea army, to which all the other component parts are but subsidiary. The French habitually speak of *les armées de terre et de mer.* The analogy between a land army and a sea army is often so close that at some points it merges into identity; and in certain problems of war the two may be reasoned upon as identical. Thus the main body of the land army, composed of infantry, may be compared to a fleet of battle-ships. The infantry of the line acts in masses, and on the field of battle constitutes the principal fighting force. The same is true of a fleet. Well disciplined, a mass of infantry in column or in square is almost impenetrable. Witness the terrible, but fruitless, charges of the French cuirassiers on the solid masses of the English infantry at Waterloo. One of the great lessons of war is that cavalry charges, except against cavalry, are indecisive unless supported by infantry. Says Hamley, in his "Operations of War": "All the formidable inroads of

Napoleon's horsemen on the British line availed nothing, for the want of infantry support." The same principle, precisely, applies to the operations of the sea army. The inroads of cruisers, which are analogous to cavalry, will avail but little unless supported by battle-ships. This position is incontestable. Napoleon regarded the infantry as the arm of battles and the sinews of the army. Infantry, in short, is the first instrument of victory. It finds a powerful support, however, in the cavalry and the artillery.

These tenets are admitted by all military writers, and are universally accepted. Let it now be asked how an army could be organized without infantry of the line. The soldier would probably answer that the question is an absurd one and unworthy of a serious reply. And yet that is just what we are trying to do with our sea army, otherwise known as the navy of the United States. That is to say, we are pretending to build up a navy without the constituents of a line of battle. We are building cruisers of various sizes, which correspond to the cavalry and light artillery of the land army; and we have monitors for coast and harbor defense, which supplement our fortifications; but we have no battle-ships to correspond to the infantry of the line, which constitutes the main strength of the line of battle.

James, one of the best historians of the English navy, remarks that the strength of the navy is the line of battle, rather than its detached or frigate force. "The latter may cruise about," he says, "and interrupt trade, or levy contributions on some comparatively insignificant colonial territory; but it is the former that arrays itself before formidable batteries and strikes dread into the heart of the parent state." Vice-Admiral Penhoat, a distinguished officer of the French navy and an author of note, reaches the same conclusion. "The most powerful agent that can be employed for the defense of the coast," he observes, "is the fleet of line-of-battle ships. That is the active force of all others that is capable of defending any point on the coast that may be threatened by an enemy."

After discussing the necessary qualifications of a battle-ship, he says: "It will be seen, from what has preceded, that the fleet of the line is the foundation of a navy; and that no operation at sea of importance, such as bombardments, the transportation of troops, etc., etc., can be undertaken with security unless the enemy's fleet of the line has first been rendered powerless."

"It is the line of battle, then, which should take precedence in its development over those accessory forces which, when joined to it, constitute together a navy. The secondary forces, the cruisers, transports, armored coast-guards, etc., should each, according to its importance, have a certain relative proportion to the whole; but they should not impede the development of the principal power."

The policy thus clearly lined out has been advocated by the executive and combated by the legislative branch of the United States Government since the beginning of our existence as a nation, and up to a comparatively recent period; and describes accurately the course followed in England, where everything relating to the navy is done seriously and with a definite purpose. Chief Engineer J. W. King, U. S. N., in his admirable report on "European Ships of War," under the head of "The British Navy," writes:

"It is to the production of the most powerful sea-going fighting ships that the resources of the navy are first directed: ships sufficiently armored to resist the projectiles of any ordinary kind; sufficiently armed to silence forts, or to meet the enemy under any conditions proffered; sufficiently fast to choose the time and place to fight; and sufficiently buoyant to carry coal and stores into any ocean."

This statement finds emphatic confirmation in the recent admiralty programme announced by Lord George Hamilton, the First Lord of the Admiralty. In brief, that programme calls for the building, between April, 1889, and April, 1894, of seventy vessels of war, ten of which are to be battle-ships and sixty cruisers of different types. The report says: "A battle-ship when completed is not entirely efficient unless she has certain small vessels attached to her as scouts; and we consider that out of the seventy vessels, twenty are satellites of the battle-ships. The remaining cruisers will be effective whether used in squadrons or individually. . . . Later on, when an increase is made to our battle-ships, each battle-ship will be accompanied by two smaller vessels; and thus there will be no drain upon our force of independent cruisers."

The strength of the British line is to be brought up in the near future to something over one hundred battle-ships, with cruisers, great and small, in proportion.

Let us now suppose the battle-ship to be subtracted from the floating force of Great Britain. How long could she hold Gibraltar and Malta, control the Suez Canal, and maintain her Indian Empire, by the eastern route? How long could she hold the line from

London to Halifax, Esquimault and India, by the western? How long could she prevent Germany from establishing a military port on the Scheldt? How long could she hold the great strategic points at Jamaica, Barbadoes, and St. Lucie, which dominate the West Indies, the Spanish Main, and the Isthmian Canal, which will eventually open to her a short cut to the Pacific? Without battle-ships the whole British Empire would crumble to pieces, "and, like the baseless fabric of a vision, . . . leave not a rack behind."

In the absence of anything and everything that might resemble a naval policy, we have reversed the usual order of naval development. The battle-ship being the very foundation of a navy, and the United States having no battle-ship, it is plain that in a military sense—the only sense in which a navy can be discussed—she has no navy. Not only that, but she has no foundation whereon to build one. She has the accessories only—the satellites, the cruisers, and the coast-guard ships. The great central body about which the satellites revolve—the solid masses of the line, which give the cruisers moral and material support—are altogether wanting. In military parlance, we have a few light infantry (cruisers) for scouts, and cavalry (cruisers) for reconnoitering; but, in case of repulse, there is no main body of the line to fall back upon. One of the functions of light infantry is to protect the flanks of the army. Our cruisers are to protect the flanks of—what? Nothing! There is no main body, no line of battle, no battle-ship, no navy—nothing, in short, but accessories.

Let us test the truth of this. International complications arise of such a character that the government finds it necessary to send a number of our best ships to a distant point—Samoa, for example. On reaching the place designated, the American admiral, in the Baltimore, as flag-ship, and accompanied by the Newark, Philadelphia, and San Francisco, all splendid 4000-ton ships of the most approved types, finds himself confronted by four battle-ships to dispute his way. The vital parts of the foreign ships and the crews are well protected by heavy masses of steel; while the sides of the Baltimore and her consorts, though of steel, are but little thicker than a single number of *The North American Review*, or, to be exact, five-eighths of an inch thick—sides of no greater powers of resistance than the frigate Constitution, launched in 1797, possessed. Do the people of this country expect their admiral to risk a battle under such circumstances? Hardly, for those ships were designed expressly to run away from battle-ships, as will presently be shown. That is the fundamental idea which is guiding the development of the new navy: to run away.

It may be observed here that the word fleet is sometimes used to express the entire floating force of the navy. This use of the word is common both in England and in France. In a more limited and technical sense, a fleet is an assembly of twelve or more battle-ships. Used in this latter sense, Great Britain will soon be able to put afloat seven or eight fleets, each fleet filled up to its tactical complement of twelve battle-ships; each battle-ship accompanied by two satellites, with cruisers, torpedo depot-ships, and hospital-ships: while cruisers, acting independently, will be left to protect her own commerce and annihilate that of an enemy. If the military necessities of England compel her to maintain, say, six fleets and their accessories, and the great powers of Europe keep afloat proportional numbers, is it not to the interest of the people of this country to have a floating force of something more than mere accessories? Is it not to the interest of our people to have a navy in reality, instead of the semblance of one? Is it not to our interest to have at least one fleet of twelve battle-ships? That is the question the Executive has been presenting to Congress for the past one hundred years.

With all her enormous iron shipbuilding facilities, England allows from three and a half to four years to build a battle-ship. In this country it would probably take a little longer. The keel of the Chicago, which is not a battle-ship, was laid in 1883, and she is not yet ready for sea; and this at a time when the government is much pressed for ships. Should either of the battle-ships Maine or Texas ever be launched, her time on the stocks will probably cover a period of from seven to eight years. Making the most liberal allowance for increase of skilled labor in iron shipbuilding, it would be twenty years at least before the United States could get a fleet of battle-ships to sea, and in these days wars are reckoned by months. If the American people contemplate building up a navy, it is not a day too soon to formulate some definite plan of development beyond mere accessories.

If there is any one fact made clear by the history of the past, it is the true function of our navy. The rôle of a navy is essentially offensive, as contrasted with seacoast fortifications, which are defensive. This broad distinction must be borne in mind, if the persistent but unavailing efforts of our highest naval authorities, in time past, to organize a navy, are to be understood.

"The proper duty of our navy," it was declared long since, "is not coast or river defense; it has a more glorious sphere—that of the offensive. Confident that this is the true policy as regards the employment of the navy proper, we doubt not that it will in the future be acted on as it has been in the past; and that the results, as regards both honor and advantage, will be expanded commensurately with its enlargement. . . . In order, however, that the navy may always assume and maintain that active and energetic deportment, in offensive operations, which is at the same time so consistent with its functions and so consonant with its spirit, we have shown that it must not be occupied with mere coast defense."

The great principles on which our entire system of seacoast defense has been erected have been laid down with mature deliberation by our highest military and naval authorities. "The means of defense," say they, "for the seaboard of the United States, constituting a system, may be classed as follows: First, a navy; second, fortifications; third, interior communications by land and water; and fourth, a regular army and well organized militia."*

The term navy is defined as "that portion only of our military marine which is capable of moving in safety upon the ocean and transporting itself speedily to distant points." This can be done only by battle-ships equal, if not superior, in fighting power to the average battle-ship of a possible enemy. "Floating batteries," etc., were regarded as pertaining to land defenses, and were deemed "powerful auxiliaries." "The navy," it was said, "being the only species of offensive force compatible with our institutions, it will be prepared to act the great part which its early achievements have promised and to which its high destiny will lead."

Benjamin Stoddert, our first Secretary of the Navy, thoroughly understood the office of a navy. In a communication to the House of Representatives under date of December 29, 1798, after advancing the most cogent reasons, he recommended the building of twelve battle-ships and as many frigates. "Had we possessed this force a few years ago," he adds, "we should not have lost, by depredations on our trade, four times the sum necessary to have created and maintained it during the whole time the war has existed in Europe." In a subsequent report, January 12, 1801, the secretary enunciates a sound principle. He says, in effect: Let our enterprising privateersmen prey on the enemy's commerce. The government should "attend principally to a provision for battle-ships and frigates." The two reports are noteworthy as clearly indicating the true lines of naval development, by the building, first of all, of battle-ships, and showing that the preying upon an enemy's commerce was altogether secondary and not the first objective of the navy.

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*It may not be out of place here to explain that in classing the navy, which is the arm of offense, among the elements of defense, the words are to be taken in their military sense. Thus we have many instances in history of "defensive-offensive" campaigns, where the defense takes the initiative. The true war of defense, military writers affirm, seeks every occasion to meet the enemy. The French defend themselves by attacking.

It cannot be said that Congress responded with alacrity to these earnest appeals. We were paying tribute at the time to the Barbary powers. French cruisers were depredating our commerce, and English vessels of war were impressing seamen out of our merchant vessels; but the navy which could, and eventually did, put a stop to these indignities, found little favor with our national legislature. The Naval Committee, reporting to the House, December 17, 1811, said: "The important engine of national strength and national security, which is formed by a naval force, has hitherto, in the opinion of the committee, been treated with a neglect highly impolitic, or supported by a spirit so languid as, while it has preserved the existence of the establishment, has had the effect of loading it with the imputations of wasteful expense and comparative inefficiency."

We were on the verge of war with England when this "languid spirit" in regard to naval affairs prevailed in the House of Representatives. In 1799 Congress had authorized the building of six battle-ships; but, the amount appropriated being insufficient, no steps had been taken towards setting them up, beyond the purchase of some ship timber, so that a few frigates and sloops-of-war were all we had of a navy.

On the 19th of June, 1812, war was proclaimed against England. Elated by the success which attended our little navy in its first encounter with the English at sea, Congress, now that the war was actually begun, authorized the President, "as soon as the materials could be procured," to cause to be built, equipped, and employed, four battle-ships and six frigates. "This was the first step," says Cooper, the historian of the navy, "that was ever actually put in execution towards establishing a marine that might prove of material moment in influencing the results of a war." But—and this is one of the impressive lessons of history—although hostilities lasted two and a half years, the first battle-ship to be launched, the Independence, was too late to take part in the war. The successes attending the war of 1812, and the placing the Navy Department upon a better footing by giving the Secretary of the Navy a staff of experienced officers—the Navy Commissioners—to assist him in his duties, excited a passing interest in naval affairs. This was not a little enhanced by the brief war of 1815 with the Barbary powers. Under the impulse of this feeling, Congress authorized the augmentation of the navy to twelve battle-ships. Owing to the limited amount of the annual appropriations, and the small number of seamen allowed by law, but four of them were kept in active service. Three were, during many years, laid up "in ordinary," and five held in reserve on the stocks in such an advanced stage of completion that, on the first sign of approaching hostilities, they could have been launched and equipped for sea in a comparatively short space of time. Built of well seasoned live-oak, they could almost be said to defy the ravages of time. They were broken up, or diverted to other purposes than originally intended, only when the type of battle-ship they represented had become obsolete. They were, with but two exceptions, the very best specimens of naval architecture of the period, and distinctively American in weight of batteries, great strength, capacity, sea-going qualities—everything, in short, that constituted a high order of excellence in a battle-ship of their day.

A flag-ship, it may be remarked, is a fair exponent of the strength of a navy. In the noontide of our naval power, the flag (or broad pennant) of the commander-in-chief was flown by a battle-ship. To-day it is displayed either from a second-rate, that has already reached the limits of usefulness, or from a third-rate but little better off. These are soon to be replaced by a class of flag-ships whose character shall be portrayed later on.

In 1823 President Monroe announced the doctrine which has since taken his name. It embraced two interdependent parts—one political, one military. The former only is now remembered. The formal declaration that the American continents "are not to be considered as subject to colonization by any European power" carried with it an obligation to maintain the means by which that policy could be enforced. Hence the President's admirable letter of January 30, 1824, to the United States House of Representatives against an undue reduction of the navy. The message was accompanied by a letter from the Secretary of the Navy, in which the naval policy of the government was plainly stated.

"When the vessels now authorized by law to be built," he writes, "are completed, there will be twelve battle-ships . . . The vessels having been built, we must train officers to command and manage them . . . A great portion of the science of the naval commanders can be acquired only on the ocean and by years of labor and discipline."

Accompanying these letters was the draft of a bill for a naval peace establishment; but it found little favor in Congress, and nothing was done.

In 1836 we had reached the meridian of our naval power. On the 18th of February of that year the Senate passed a series of resolutions, one of which ran as follows: That the President be requested to cause the Senate to be informed of "the probable amount that would be necessary to place the naval defense of the United States upon the footing of strength and respectability which is due to the security and to the welfare of the Union."

The Executive replied that "the force to be prepared ready for use when circumstances may require it should consist of fifteen battle-ships, twenty-five frigates, twenty-five sloops-of-war, twenty-five steamers, and twenty-five small vessels, and that the frames, ordnance, etc., should be prepared for ten battle-ships and ten frigates." It was proposed, further, that six battle-ships, eleven frigates, fifteen sloops-of-war, and a number of smaller vessels should be kept in active service during peace, "for the protection of our commercial interests, and to prepare officers and others for the efficient management of the force proposed for a state of war." The year 1850 was fixed upon as the most remote period at which the proposed force ought to be ready. The board was of the opinion, however, that it might be prepared much sooner, "should Congress deem it advisable to make larger appropriations than those suggested." But Congress did not "deem it advisable"; indeed, did not deem it advisable to make any increase whatever. Six years after making their report, the able staff of the Secretary of the Navy—the Navy Commissioners—were legislated out of existence, and the year 1850 passed, and 1860, 1870 and 1880, and now we find ourselves approaching the year 1890, and instead of a "gradual increase," there has been a gradual degeneration of the navy, and we have not to-day a single battle-ship to succeed those launched in 1818–20.

The decline of our naval power cannot be attributed to a radically defective form of naval administration alone, though that is responsible for much of the evil. There is another cause. According to natural laws, the military and mercantile marine of a state rise and fall together. The exception to this law is when a purely military policy compels the maintenance of a war marine; and we are not a people to exercise military prevision.

In the early days of the world's history war-vessels were needed to keep down piracy and enable traders to pursue their way in peace. An extensive commerce begot distant colonies, and both required the constant protection of a war marine. Then a navy came to be an exponent of a nation's wealth and power. The commerce and navy of Tyre grew together, and together fell. Carthage in her days of prosperity monopolized the trade of the Mediterranean, and her navy for a time defied the whole power of Rome. During the middle ages, the Italian Republics, Venice and Genoa, had large interests in commerce and powerful navies. With the loss of the one the other passed away. Spain, Portugal, and Holland, each in its turn, went through the same experience. England presents the greatest example in history of enormous wealth acquired through foreign trade. Colonial possessions followed, and a navy which defies the united forces of any two maritime countries in the world was the natural result.

For a time the United States followed England in her extension of ocean commerce. The American flag became a familiar sight on every sea, and the tonnage engaged in our foreign trade ran up to be second only to that of England. But our foreign shipping had already begun to decline before the breaking out of the rebellion in 1861. Our people were, and are, content to have their carrying trade borne in foreign bottoms, and to see what was once a source of national pride and strength and power, transferred to foreign flags to help make their countries rich and strong. Having sacrificed a large measure of our shipping interests, and with no outlying possessions to protect, what more natural than that there should be a decline of our naval power? Blind or indifferent to the military aspect of the question, the resultant of the several causes has forced the navy to abandon its principal and time-honored rôle as the offensive arm of the government, thrown it back upon the lines of defense, and gradually withdrawn it from the sea. The tendency of the entire navy now is to get on shore and stay there.

The "new navy" took its rise in 1881. The very term is suggestive. It is peculiar to this country, and indicates our methods of procedure in all matters connected with naval affairs. In the maritime countries of Europe naval architecture kept pace with the changes that have been going on for years past in naval and military science. Marine architects and their artisans moved with the times; and the naval officers and seamen had no difficulty in adapting themselves to the continuous, but gradual, changes. These changes were brought about by such slow degrees that there was no precise date to mark the decease of an obsolete type of ship and the birth of a new. It was not so in the United States. On the close of the war of the rebellion we sat down to rest. What mattered it though we had given the Monitor to the nautical world, and a fresh impetus to marine architecture? We ourselves sat down to rest. The building of vessels of war, in which we had once led the navies of the old world, became to us a lost art; and a quarter of a century after the Monitor had effected a revolution in the art of naval warfare, we find ourselves compelled to go abroad for the models of our war-ships; meanwhile having our naval constructors educated in foreign schools of naval architecture. The building of the battle-ship Texas from English designs marks a distinct era in the history of the United States Navy.

For twenty years from the war of the rebellion the Executive had been urging the augmentation of the navy with monotonous iteration; but the people, or their representatives in Congress assembled, would not have it. What wonder we should drop from the list of sea powers? The first Advisory Board was instructed to "recommend such vessels as Congress would be likely to approve"—not what, in the judgment of the Executive, the country ought to have, but what it could get. This was the lesson of generations of experience in naval administration. The board reported, therefore, that as the limit of money Congress would be willing to appropriate for the navy was, without doubt, a very restricted one, the construction of ironclads (battle-ships) was not recommended, though "such vessels are absolutely needed for the defenses of the country in time of war; and if Congress be willing . . ." But, as in 1836, Congress was not willing. Hence the plan for the new navy was not for a navy at all, but for a sort of *pis aller*.

The new steel cruiser upon which we pride ourselves—and justly so—is designed, as already stated, with a special view to run away from battle-ships. She must be able to escape from ironclads, and outrun, so as to capture, merchantmen. "If slower than ironclads, she could not keep the sea; and if slower than merchantmen, she might as well remain in port." (Report of the Secretary of the Navy, December 1, 1888.) This is all very well, but fifty years ago we could have sent to sea a squadron of ten battle-ships that would have compared favorably with those of any nation on the globe, and to-day we have none.

It is true we have the keels of two battle-ships on the stocks, and they may be finished and even sent to sea before the types they represent become obsolete. Even that addition to the navy would avail but little unless they are the forerunners of others. In 1836 the official programme called for fifteen battle-ships. To-day we need twenty at least. When we shall have put one-half that number afloat we may begin to talk about "rehabilitating" our navy without provoking a smile of derision.

But the people, or their representatives in Congress, are not willing to rehabilitate in that sense. Hence the United States Navy of the future is to be made up of coast-defense vessels, which, according to our custom, will be laid up "in ordinary," and thin-sided steel cruisers for the high seas. Consequently the American flag is to be displayed upon the ocean only by vessels designed to prey upon private property, and this notwithstanding our own proposition to amend the rules of international law by exempting private property at sea from capture.

During the Franco-German war in 1871 it was the French battle-ship that dominated the North Sea. The preying upon the private property of the citizens of either belligerent played a wholly insignificant part in the war. And yet that part, insignificant as it is in a maritime war, is the principal objective of the United States Navy of the future. Thus do we virtually abdicate our position as a sea power.

Kinglake, in his "Invasion of the Crimea," draws, with pardonable pride, a fine picture of the moral effect of the presence of an English man-of-war. It was just before the battle of Alma, when, "as though in arrogant yet quiet assertion of an ascendant beyond dispute, one solitary English ship, watching off the Sebastopol harbor, stood sentry over the enemy's fleet. Men had heard of the dominion of the seas; now they saw it." That "solitary ship" represented the vast, living power of a people ever ready to wield it.

A solitary American steel cruiser, with its delusive prefix of "protected," represents the latent possibilities of a great country placidly awaiting some national disaster to generate its mighty forces.

DISCUSSION.

Ensign **Bernadou.**—I have read with care the interesting and valuable paper now under discussion. While realizing the great advantages in the way of increasing national prestige that would speedily result from the creation of a fleet of battle-ships, yet I cannot but believe that a different line of development would be more in keeping with our present interests.

The problem seems to me to be how, with a moderate appropriation continued through a series of years, to build up a navy that will enable us, first, to defend the approaches to important points on our coasts, and to extend the defensive radius at these points until it equals the radius of offense of modern ironclads; second, to assume an offensive up to distances, say of 3500 miles; third, to injure an enemy by crippling his commerce. For these purposes there would be four classes of vessels needed: coast defense vessels in kind and number proportionate to the requirements of the various sections of the coast; torpedo-boats in great number; a moderate fleet of ironclads; protected cruisers, swift and of great coal endurance.

I think that we should develop these vessels as rapidly as possible, bearing in mind our needs in the order of their importance, which I take to be as follows: protection of our coast cities; protection of our commerce; maintenance of our national policy. Let us therefore begin by building coast defense vessels, heavily armed and well protected, light of draught and of good manœuvring powers.

With the ultimate object of protecting our commerce at sea in time of war, let us in time of peace aim directly at increasing the efficiency of our cruising squadrons, and continue to build protected cruisers of high speed and endurance, well armed with numbers of rapid-fire guns.

Finally, to every five of our coast defense vessels, say, let us build one seagoing armorclad, a powerful vessel primarily intended for defensive purposes, but able to act on the offensive when needed. To obtain this latter capability we must lighten draught and therefore increase beam; by so doing we sacrifice speed, but we gain by being freed from the necessity of constructing enormous hulls on speed lines.

I consider that the importance of commerce-destroyers is overrated; for the chief lines of trade of the world, at present, either emanate from our own country, or else skirt the western coasts of Europe, where merchant vessels could easily be protected by any European power; *e. g.*, by convoy from headland to headland. I say this to emphasize my belief that we should go ahead rapidly with the construction of our coast defense vessels, and take a more moderate pace with other types.

As to what our navy shall be at sea in times of peace, I think that we may borrow ideas from the system followed at present in Germany, where, at such times, ironclads are kept at home, partly manned or in ordinary, to be fully manned and exercised at stated times; while lighter vessels are sent abroad. Were battle-ships used by us as flag-ships, we would find, in time of trouble, a large number of our best vessels—doubtless constituting an important fraction of our offensive forces—scattered over the waters of the globe, and in these days of quick action there would be no time to assemble them.

Let us run for the present the risk that a lack of torpedo-boats would entail, and get them when appropriations for larger craft are not forthcoming.

Captain MAHAN.—I have only to express my entire concurrence in the general tenor of this admirable paper, and in the principles of naval policy adopted in it. Such being the case, having nothing to criticise and little I should care to add, I would have said nothing, were it not that the matter is so important to the country and to the service that it is desirable to re-enforce the paper by as large a consensus of professional opinion as can be obtained.

It is much to be hoped that the whole question of dependence upon swift cruisers and commerce destroying, as a principal mode of warfare, may be more seriously considered than it has been by the navy. If I am right in my opinion, which I understand to be that of Admiral Luce as well, that a war against an enemy's commerce is an utterly insufficient instrument, regarded as the main operation of war, though doubtless valuable as a secondary operation, the United States and its people are committed to an erroneous and disastrous policy. No harm has been done in building the new cruisers, for ships of that kind are wanted; but great harm has been done by the loss of so many years in which have not been built any battle-ships, which are undoubtedly the real strength of a navy.

Lieutenant WAINWRIGHT.—Admiral Luce has clearly struck the keynote of our naval policy, and there must be very few naval officers who do not know that the present necessity for the navy is to create a fighting force, viz., to build battle-ships. The great value of his article is that he so clearly and interestingly exemplifies the point as to impress it upon the general public. All naval officers must be convinced that the real reason for their existence as such is to fight in case of need, and that while useful and ornamental in time of peace, they will be of little ornament and no use in time of war without battle-ships. The public have heard so much of the fine navy that has been building for some years past that they imagine the United States Navy has considerable fighting power. Admiral Luce's paper is well calculated to disenchant their minds of this fallacious impression. Then it is for the people of the United States to say whether they will properly protect their immense interests, or leave them under the doubtful shelter of a limited number of desperate expedients.

I do not think that it was a mistake to begin by building unarmored cruisers, because at the time the new navy was commenced the want of plant or experience necessary for building vessels of war would have prevented our building armored vessels in anything like reasonable time. It was very sensible to gain the experience on the less complicated ships and to gather the plant slowly. Now we have the plant and the experience, everything necessary but the appropriation. It is to be hoped that the public will recognise that battle-ships are necessary to oppose battle-ships, that until they are provided a large proportion of the wealth of the country is at the mercy of any maritime power, and, furthermore, that it takes years to build a battle-ship. They must learn that fortifications, mines, floating batteries, and torpedo-boats are auxiliaries to the main defense, that by their means they may protect some points of the coast from actual assault, but not all, and beyond this that by none of these can they prevent blockade. Let this idea strike in and we will have battle-ships. It will only then be necessary to determine the quantity and quality. The quantity may be determined by the force maintained by the strongest probable enemy. He will be able to devote a certain proportion of his battle-ships to attack us. If we have suitable auxiliary defenses such as fortifications, mines, torpedo-boats, and coast defense vessels, our fleet of battle-ships may be smaller than the one he can send against us, for not only can we count upon the aid of the coast defense vessels, but also he will be unable to accomplish anything unless he can mask our fleet. Taking this into consideration, it would seem as if the twelve battle-ships mentioned by Admiral Luce were the smallest number sufficient to give a fair amount of security to our coast.

The type of battle-ships to be selected is a far more difficult problem, and the American battle-ship of the future has yet to be designed. With a small number of battle-ships, all of them must be able to enter our principal ports, and this puts a limit on their size. They must have the necessary battery, protection, speed and endurance. As their main sphere of usefulness will be near our own coast, they might have less coal endurance and a smaller supply of ammunition than foreign battle-ships of the same size, and this saving of weight could be used to increase the weight of battery or armor, that is, in coal endurance they would have a little less than ordinary battle-ships and more than coast defense vessels.

Whatever the type selected may be, we must have battle-ships, and we may rely upon it we have talent enough in the navy to design the best that can be built within the necessary limitations, if the task be assigned and the money be forthcoming.

Commander HARRINGTON.—Great Britain possesses 71 armored vessels, of an aggregate displacement of 509,000 tons and cost of 131 millions of dollars. Of these, 27 ships, of a total displacement of 224,000 tons, have been built since the year 1880 at a cost of 70 millions of dollars. About 50 per cent of the naval force in armored vessels is of more recent design and construction. Nevertheless, 8 armored battle-ships of 14,150 tons each and 2 of 9000 tons each, an aggregate of 131,000 tons, are building and to be completed by April, 1894, at an estimated cost of 42 millions of dollars.

The unarmored cruising navy of Great Britain is composed of 182 vessels, of an aggregate displacement of 316,000 tons, and cost of 71 millions of dollars. Of these, 118 vessels of 204,000 tons have been built since 1880 at a cost of 47 millions of dollars. (The protected cruisers are included.) About 64 per cent of the unarmored and protected cruising navy is of more recent design and construction. Nevertheless, 60 cruisers, of 188,000 tons displacement, and estimated cost of 43 millions of dollars, are to be added to the navy by April, 1894.

The torpedo-boats owned by Great Britain number 147, costing nearly seven millions of dollars.

All the figures relating to cost of this navy are exclusive of the cost of armament.

Assuming that the power of armament is proportional to the displacement of the vessels carrying it, we find that about 60 per cent of the cruising naval force of Great Britain is placed in armored ships.

The vast sums of money which the people of Great Britain willingly spend upon their navy is the insurance of a mighty sea trade and the cost of maritime empire. No other country has such interests upon the sea, and none has emulated Great Britain's naval expenditures. Naval force is maintained by each nation with a primary regard to its necessities, defensive or otherwise, however limited by difficulties of finance. The number of torpedo-boats relates to the number of ports and the extent and navigability of coast. Fast cruisers are necessary to any country which, like Great Britain, has numerous ocean lines of commerce to convoy and protect; and they are desirable for any country to raid the commercial routes of a possible foe. The number of armored battle-ships is determined not only by the demands of coast defense, but by the existence of colonies, by obligations of protection or defense voluntarily conferred upon distant countries or people, by international relations in general and the part and influence it is intended to exert upon the sea and in the affairs of the world.

The necessities of foreign countries, as illustrated by their naval constructions, do not present a measure of the amount of naval force required by the United States; but in regard to kind and quality, foreign navies offer most useful suggestions to a country just entering upon naval construction. The composition of a naval force should have a direct relation to the kinds of weapons employed by people who may become enemies. Gunboats are not built to oppose cruisers, nor cruisers to engage armored vessels. It will happen that vessels of different classes or types will meet on unequal terms. An instance has occurred in which several cruisers designed the capture or sinking of an armored ship, chiefly by ramming. Victory has often declared for the weaker antagonist using superior gunnery, strategy, or tactics, or has turned upon some fortuitous circumstance of battle. For such reasons and with such hopes, men will take the risk of odds in number and kind of weapons. But these conflicts are infrequent and arise under exceptional circumstances. As in the past, the cruiser or frigate which comes in the future under the guns of a battle-ship will be captured or destroyed. Modern cruisers are built with greater speed than armored vessels, upon the distinct idea and expectation that they will not usually pass under the guns of a battle-ship. In other words, they will run from an armored vessel, except under circumstances which will justify exposure to its battery. Ships armed for combat seek their own types of antagonists, but avoid their superiors. Undue neglect of the higher types is a fault of naval policy which confirms a naval inferiority.

Great Britain's need of fast cruisers rises with the extent of her ocean traffic. These vessels must have great coal endurance, and, as their speed must be maintained in heavy seas, they must have great length and draft.

Accordingly, there is a marked increase in the displacement of the later cruisers. The average displacement of the vessels of the existing unarmored navy of Great Britain is about 1740 tons, while that of the additional sixty cruisers building is 3138 tons. Forty-two of the latter average 4168 tons, the remaining eighteen being torpedo gunboats of 735 tons. The number of cruisers is controlled by the conditions of Great Britain's commerce ; but for that vast interest, the armored battle-ship of less speed would be preferred for war service. This reasonable desire for armor, in a vessel which may have to do heavy fighting in convoy duties, has brought into existence the armored cruiser, which embodies in a modified degree the heavy battery and armor of the battle-ship together with the high speed of the vessel known as the protected cruiser. The convoy of fast steamers will be the most important office of the armored cruiser, although a weapon but little inferior to the battle-ship.

The United States has no existing interest of ocean trade, comparable with those of Great Britain and other countries, demanding the creation of a large number of unarmored or merely protected cruisers. Upon a declaration of war sailing vessels will be laid in port. Merchants will not be able to place them under a neutral flag, since such a transfer subsequent to a declaration of war will not be respected. Much of the coastwise trade will pass to the railroads and internal traffic routes. Commerce, externally, must be carried on by fast steamers. The cruisers, then, will engage in their contemplated duties, as despatch vessels, as lookouts along the coast and to the fleet of battle-ships, in convoying, and in preying upon the commerce of the enemy. The vast enlargement of internal industries and traffic in our extensive country has absorbed the energies and capital of our people. Under new conditions of money and labor, when both seek new enterprises, whenever external commerce shall offer fair profit, the United States will acquire fast merchant steamers. Capital will then seek foreign trade in proportion to the existence of means of protection, the visible assurance in every part of the world that the country is resolved to defend the property of its citizens upon the sea as well as upon the land. It is the confident hope of the establishment of an American sea trade, carried under the flag of the United States, which justifies the construction of numerous cruisers for our navy.

Cruisers cannot prevent the descent of a hostile naval force upon a coast. The approach of such a force could be reported by cruisers, giving warning by signal and telegraph to all threatened points ; but it is only a line of battle-ships which can stop a hostile fleet or control its selection of a point of attack. The enemy cannot raid the coast or attempt to lay a city under contribution while subject to an attack in rear. He must seek and defeat the fleet defending the coast before venturing upon any territorial operation. The defending fleet limits the movements of the enemy from the moment the former gets touch through its cruisers with the latter, and the defense may even choose the time and place of action. When there is no fleet the local defenses must be numerous and extensive, and there are many localities upon a coast which cannot be defended, either wholly or in part, by fixed batteries. When there is no defending fleet the enemy may often do pretty much as he pleases, and can always secure harbors for the use of his force in the vicinity of intended operations. The French ruled the seacoast of China in 1884-85 because the Chinese could not oppose to them a line of battle separated from the local defenses. The dominant fleet defending the Chesapeake in September, 1781, secured results momentous to this country. The non-existence of a fleet of defense in 1814 gave Washington into the hands of the enemy.

Rams and sea-going battle-ships can preserve control of the coast waters and give immunity to the coast from naval attack and bombardment. An armored fleet is otherwise necessary to the dignity and honor of the country. The United States has incurred obligations abroad which have been and can be discharged, without a fleet, only during the non-interference of foreign powers. A principle of rule upon the American continent rests upon the *latent* power of a great country, a precarious support which may be affected by the interests or ambitions of other great nations. Not many years ago an impending war with a foreign country found the United States without proper means of coast defense, and without weapons to compel a compliance with its demands.* Had war ensued, our country, doubtless, would have been victorious at last, but, perhaps, after losses and humiliations. The construction of an interoceanic canal, owned by citizens of the United States, and the establishment of a trade under our flag, will increase the number of those occasions upon which the country should show its readiness and ability for immediate defense of its rights abroad as at home. The means must be proportioned to the ends desired: cruisers, torpedo-boats, and torpedo gunboats will not suffice.

The recent development of the quick-firing gun and high explosives has given a new value to armor. In addition to protection of a ship's machinery and buoyancy by protective decks and water-line armor and cellulose belts of suitable thickness, a moderate thickness of armor must be placed about the batteries to prevent the explosion of detonating shell among the crew, and so insure the uninterrupted service of the guns.

In the Baltimore and our newest cruisers, the protective decks are of such thickness and position as insure the floating of the ship under a heavy pounding of projectiles. This measure of safety to buoyancy and machinery is independent of the uncertain coal protection, which may or may not exist at the time of action. The special danger of these vessels is the slaughter of the crew by quick-firing gun projectiles, within the distance at which the fire of that gun may be corrected successively. In a word, they are not close-action ships, though they may rightly engage at any distance vessels of their own type and similar armament. Their tactical distance for action is determined by the primary battery, but modified by the absence of adequate protection against the shorter range quick-firing gun. It is of such vessels that the London *Army and Navy Gazette*, reviewing the United States Navy, recently used the following language: "It will be seen that the United States are in earnest in the intention of resuming their position as a naval power. It is, however, somewhat significant that at present all this construction seems to tend in the direction of vessels more fitted to run away from an antagonist of real weight, than to sustain the glorious traditions of the American sea service.

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*Officers of the navy will remember how hospitably we received, at this time, in one of our navy yards, an ironclad belonging to the country referred to.

With but one or two exceptions these ships are better prepared to destroy commerce than to protect it. There is no sign of a fleet fitted to cope with European armorclads if they crossed the Atlantic, as they have done before. After all, though, it is better to crawl before trying to run, and we may yet see designed, laid down and built by native talent, in a United States navy yard, that crux of naval construction, the 'battle-ship of the future.'"

The designs of the British armored ships Nile and Trafalgar and the Italian Re Umberto have been changed in order to provide protection against detonating shell. The British Admiralty, in possession of the results of experiments with detonating shell and quick-firing gun projectiles, gave four inches of armor about the auxiliary armament of the new battle-ships, and, subsequently, available displacement in the designs was utilized by increasing slightly that part of the armor. Armored ships building for Chili, Greece, and Russia have a similar feature.

In the Dupuy de Lôme and other side-protected cruisers of the French navy, the battery armor is four inches of steel. The water-line armor is reinforced by a coffer-dam filled with obturating material. The new British cruisers of the first class are to have similar protection to their batteries, notwithstanding an increase in the protective deck to a maximum thickness of five inches. It is but a step in the further development of such vessels to the armored cruiser and the battle-ship.

As we have seen, the marked drift in construction of cruisers is armor for batteries and external protection, as well as internal armor to preserve the buoyancy and stability; and we must inevitably follow that tendency. The powerful battery of the Baltimore is not installed merely to harry commerce. She will fight her own kind at least. Our next first-class cruisers should meet the improved types, with which the Baltimore may not be matched on equal terms. The evolution passes to the armored cruiser, and towards that conclusion Spain, Russia, and other nations, as well as England, have turned a considerable part of their naval constructions.

In each type of war vessels our ships should equal the best afloat under foreign flags; and since the total naval force will be inferior in number to those of many nations, the navy should be composed chiefly of ships of the higher types. The Petrel and the Dolphin are very useful and economical war vessels for a time of peace, but the reason of their existence for a state of war is not apparent. Every ship should have a distinct office in war, and her construction should be determined with reference to that office. If the duty assigned is to oppose a war vessel at sea, armor is a part of construction which, at the present day, cannot be neglected.

If two battle-ships and a suitable number of auxiliary vessels are laid down annually, a quarter of a century will elapse before the naval force will be commensurate with the need of the country. A dozen armored vessels should be built as soon as the material can be obtained. While these are building, with an annual programme of additional construction duly arranged, the manning of the completed force will require some attention and legislation. But each measure, providing ships or men, should make perfect some part of a definite and lasting naval policy.

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

STEAM TRIALS OF THE ROYAL ITALIAN IRONCLAD LEPANTO.

By Major Nabor Soliani, Royal Italian Navy; Member.

Read at the Thirtieth Session of the Institution of Naval Architects, July 26, 1888; the Right Hon. Earl of Ravensworth, President, in the Chair.

[Reprinted from the Transactions of the Institution of Naval Architects, 1889.]

The R. Italian ironclad Lepanto underwent recently a series of trials at sea which are interesting, both in themselves and with reference to the size and type of the ship and the power and type of her engines and boilers. It is, in fact, the first time that a power of 16,000 I. H. P. has been developed on board an ironclad, giving her a speed of over 18 knots, and that a large number of locomotive boilers, in connection also with boilers of a different kind, have been worked together with complete success.

I have got permission from His Excellency the Minister of Marine, Mr. B. Brin, the designer of the ship, to put before this institution the results obtained, hoping that their record, enhanced in importance by the considerable amount of attention that this type of ship has attracted from the naval and the engineering world, will be a useful addition to the knowledge already gained on the propulsion of modern war-ships.

A description of the Italia, the sister ship of the Lepanto, was given some time ago in scientific newspapers (*Engineering*, February 17, 1888, p. 158), and therefore I shall restrict myself here to the principal dimensions and data of the Lepanto that have a bearing on the subject.

The principal dimensions of the Lepanto are as follows:

Length between perpendiculars, . .	400 ft. 6 in.
Breadth, ...	72 ft. 9 in.
Depth, moulded, ...	46 ft.
Mean draught, normal, ...	28 ft. 4 in.
Area of midship section, . . .	1843 sq. ft.
Displacement, ...	13,851 tons.

The ship is entirely built of steel, and has no sheathing on her bottom, differing in this respect from the Italia, in which the steel bottom is sheathed with wood and zinc.

The internal divisions are pretty much the same in both ships, with the exception of the boiler-rooms, which are differently arranged on account of the different type of the boilers.

The Italia is fitted with twenty-six boilers of the Admiralty oval marine type, divided into six compartments, three forward the engine-rooms and three aft, each compartment having its own funnel.

On the Lepanto there are also six compartments of boilers, similarly situated, as shown in Fig. 1 (Plate VI), but only the two near the engine-rooms have marine oval boilers, four in each, and the remaining four compartments have locomotive boilers, four in each, making a total number of eight oval marine boilers and sixteen locomotive boilers. Their arrangement is clearly shown on the sketch.

The locomotive boilers, which form, perhaps, the main interesting feature of the machinery, deserve special notice. There are two furnaces in each boiler, separated by a longitudinal water space, which, however, stops short of the tube-plate, leaving a passage between, above the bridge. The furnaces are just as long as the fire-grate, but to prevent the fire damaging the tubes, and to ensure a good combustion of the gases, a high hanging inclined baffle brick bridge is fitted, as usual in railway practice, in each furnace at the end of the fire-grate.

The bottoms of the ash-pits form water-pans to keep the grates cool; the latter are made with longitudinal cast-iron rocking bars.

The oval boilers have three furnaces, each discharging into one common combustion chamber. Their grates have ordinary fire-bars ¾ inch thick, with ⅝ inch interstices. There are four funnels—two for the forward set of boilers, and two for the after one.

In each set the oval and the locomotive boilers have each their own separate funnel.

The boiler-rooms are provided with twenty fans—four in each oval boiler-room, and three in each locomotive-room—capable of maintaining an air pressure over 2½ inches of water in the former, and of 4 inches in the latter.

The main engines, four in number, and arranged in four separate compartments at the center of the ship, are of the well-known type of Messrs. Penn, with three equal vertical cylinders, as applied on

H. M. ships Ajax and Agamemnon, working compound at moderate power, and direct at full power.

The cylinders are steam-jacketed, and fitted with a double ported flat-slide valve, having an expansion valve working on its back, which allows of any degree of cut-off being fairly obtained.

The main engines work their own air and main feed pumps, the circulating pumps only being, as usual, moved by independent engines.

The following are the leading particulars of the engines and boilers.

PARTICULARS OF MACHINERY.

OVAL BOILERS.

Boilers—

Number of boilers	8
Height	14 ft. 7 in.
Width	11 ft. 7 in.
Length	10 ft. 2 in.

Furnaces and Combustion Chambers—

Number of furnaces in one boiler	3
Diameter of furnaces	3 ft. 2 in.
Length of furnaces	7 ft. 4 in.
Width of combustion chamber	10 ft. 2 in.
Depth " "	2 ft. 2 in.
Height " "	6 ft. 6 in.
Capacity of furnaces and combustion chambers in one boiler above fire-grates	240 cubic ft.

Grates—

Length of grates	6 ft. 6 in.
Area of grates in one boiler	59 ft. 8 in.
Arrangement of fire-bars	Longitudinal.
Type of fire-bars	Ordinary.
Material of fire-bars	Iron.
Thickness of fire-bars	¾ in.
Interval between fire-bars	⅝ in.

Tubes—

Number of tubes in one boiler		306
Material		Brass.
Length of tubes between tube plates		7 ft. 3 in.
Diameter of tubes (internal)		2¾ in.
" " " (external)		3 in.
Area through tubes in one boiler		12.6 sq. ft.
Heating surface in one boiler	tubes	1744 sq. ft.
	total	1920 sq. ft.

Total for all Eight Oval Boilers—

Grate area		478.4 sq. ft.
Heating surface	tubes	13,952 sq. ft.
	total	15,360 sq. ft.
Area through tubes		100.8 sq. ft.
Water surface		862 sq. ft.
Capacity of furnaces and combustion chambers above fire-grates		1920 cubic ft.
Capacity of steam chamber		2560 cubic ft.
Weight of water		124 tons.

Funnels—

Number of funnels	2
Size (oval)	5 ft. 6 in. x 7 ft. 4 in.
Height above fire-grate	76 ft.
Area	80.6 sq. ft.

Ratio of—

Cube heating surface ÷ grate area	27 sq. ft.
Total heating surface ÷ grate area	32.1 sq. ft.
Area through tubes ÷ grate area	0.211 sq. ft.
Area of funnels ÷ grate area	0.168 sq. ft.
Water surface ÷ grate area	1.8 sq. ft.
Capacity of steam chamber ÷ grate area	5.35 sq. ft.
Capacity of furnace and combustion chambers ÷ grate area	4 sq. ft.
Load on safety valves	60 lbs.

Fans—

Number of fans		8
Diameter of fans	four	4 ft. 6 in.
	four	6 ft.
Type of engines		Brotherhood.

LOCOMOTIVE BOILERS.

Boilers—

Number of boilers	16
Height of boilers	9 ft. 6 in.
Width of boilers in front	7 ft. 11 in.
Length of boilers	14 ft. 5 in.
Diameter of barrel	6 ft. 7 in.

Furnaces—

Number of furnaces in one boiler	2
Width of furnaces	3 ft. 3 in.
Length of furnaces	6 ft. 8 in.
Height of crown above fire-grate	6 ft.
Capacity of furnaces in one boiler	260 cubic ft.

Grates—

Length of grates		6 ft. 6 in.
Grate area in one boiler		42.2 sq. ft.
Arrangement of fire-bars		Longitudinal rocking.
Material		Cast iron.
Type		Having side inclined combed air grooves.

Tubes—

Number of tubes in one boiler		376
Material		Brass.
Length of tubes between tube plates		7 ft. 7 in.
Diameter of tubes	internal	1¾ in.
	external	2 in.
Area through tubes in one boiler		6.27 sq. ft.
Heating surface in one boiler	tubes	1490 sq. ft.
	total	1670 sq. ft.

Total for all Sixteen Locomotive Boilers—

Grate area		675.2 sq. ft
Heating surface	tubes	23,840 sq. ft.
	total	26,720 sq. ft.
Area through tubes		100.3 sq. ft.
Water surface		1412 sq. ft.
Capacity of furnaces and combustion chambers above fire-grates		4160 cubic ft.
Capacity of steam chambers		3360 cubic ft.
Weight of water		105.6 tons.

Funnels—

Number of funnels		2
Size (oval)		6 ft. 4 in. x 8 ft. 2 in.
Height above fire-grate		72 ft.
Area		94 sq. ft.

Ratio of—

Cube heating surface ÷ grate area		35.3 sq. ft.
Total heating surface ÷ grate area		39.6 sq. ft.
Area through tubes ÷ grate area		0.15 sq. ft.
Area of funnels ÷ grate area		0.14 sq. ft.
Water surface ÷ grate area		2.09 sq. ft.
Capacity of steam chambers ÷ grate area		4.98 sq. ft.
Capacity of furnaces and combustion chambers ÷ grate area		6.16 sq. ft.
Load on safety valves		60 lbs.

Fans—

Number of fans		12
Diameter of fans	four	4 ft. 6 in.
	eight	6 ft.
Type of engines		Brotherhood.

ENGINES.

Description of engines	Three equal vertical cylinders, Penn's type.

Main engines—

Number of engines	4
Number of cylinders in one engine	3
Diameter of cylinders	54 in.
Stroke	39 in.
Number of cranks in one engine	3
Angle of cranks	120°
Collective indicated horse-power	18,000
Revolutions	96

Condensers—

Number of condensers	8
Collective cooling surface	31,300 sq. ft.

Propellers—

Number of propellers	2
Description	Admiralty.
Diameter	20 ft. 6 in.
Number of blades	3
Pitch	20 ft. 6 in.
Pitch ratio	1
Surface of blades in one propeller	80 sq. ft.

PARTICULARS OF TRIALS.

The trials were to be made in accordance with the following programme, proposed by Messrs. John Penn & Sons, and accepted by the Ministry of Marine:

1. A trial with only two oval boilers at work, and the after engines only at work on the compound system, to ascertain the most economical steaming of the ship.

2. A trial with the eight oval boilers at work, the four engines working compound.

3. Ditto with four engines working direct expansion.

4. A forced draught trial with only the after set of engines and boilers at work, the engines working direct.

5. A forced draught trial with all eight oval boilers and eight locomotive boilers at work, the four engines working direct.

6. A full-power forced draught trial or trials, with all the engines and boilers at work, the engines working direct.

This programme was not completely carried out, on account of the ship having been put in commission, which prevented the final

18,000 I. H. P. trial being made. It went, however, far enough to show what can be expected from the engines when working at their full power.

The trials were made along the eastern coast of the Gulf of Genoa, from Spezia to Genoa and back, the two runs being altogether over eighty nautical miles. A portion of the forward run from Spezia to Genoa was taken in each trial, to bring up the engines to the desired speed.

The speed of the ship was ascertained by means of bearings on well-known points on the shore in both runs.

The bottom of the ship was fairly clean, the ship having been docked on March 1, viz., about one month before the trials.

The ship was fully laden in all the trials, with very slight differences of draught.

The indicated horse-power developed was ascertained from the indicator cards of the main engines, without taking any account of the steam used for auxiliary purposes.

The trials were carried out under the direction of Mr. J. W. Fairley and Mr. May, who represented the firm, and of Mr. Holland, the engineer in charge.

All the results obtained and the conditions of trials are figured on the annexed table, and to them the following remarks will serve as an illustration.

One of these remarks is of great importance, as it refers to the behavior of the locomotive boilers, which was perfect.

After the rather discouraging experience with locomotive boilers working in sets on board some ships, as the Flavio Gioja of the Royal Italian Navy, and the Polyphemus of the Royal English Navy, some fear was entertained that similar troubles might be experienced with the Lepanto, in which the difficulty appeared to be still greater, considering the larger number of boilers to be worked together in so many different separate compartments.

But nothing of the kind happened, nay, everything went to prove the contrary.

From the beginning of the preliminary trials, which took place towards the end of last year, the locomotive boilers gave evidence of their good working, which went on increasing trial after trial, so as to be now an established fact.

They never primed nor gave any trouble whatever. The feeding was occasionally uncertain, but the fault was due to air that collected in the main feed pipe. This imperfection was removed, and on the last two trials the feeding was quite satisfactory. After each one of the last three forced draught trials the locomotive boilers had tubes leaking, but in small numbers, and not more, comparatively, than the oval boilers, which, even in this respect, did not behave better. Moreover, there were discrepancies between the different compartments of boilers, locomotive as well as oval, which show that the management of the fires has a good deal to do in this matter.

The ventilation of the locomotive stokehold is excellent. The fans being fitted on top of the boilers, no current of air strikes the floor, and a thorough cool ventilation and forced draught are obtained without any inconvenience whatever from coal dust. The same may be said of the oval boiler stokeholds, where the fans are fitted on the wings behind the boilers, but, although the supply of air is ample, the temperature does not during forced draught fall so low, probably on account of the boilers facing each other. The mean temperature of the oval boiler stokeholds was about 106° against 88° in the locomotive boiler stokeholds, while the atmospheric temperature oscillated about 58°.

The engines worked very satisfactorily all through the trials, without the slightest hitch occurring in any part of the whole machinery. This circumstance helped, no doubt to some extent, the good performance of the boilers, which had never to be checked or hampered when in full swing.

The power of 16,150 I. H. P. on the last trial was developed by the engines with a mean air pressure of 1.9 in. of water in the locomotive boiler stokehold, and of 1.6 in. in the oval boiler stokehold, the coal burnt per square foot of grate per hour being 51 pounds in the former and 38 in the latter. But as, at the preliminary partial trials mentioned above, the oval boilers were worked up to 2½ in. of pressure and the locomotive boilers up to 3½ in. with perfect success, burning 45 and 68 pounds of coal respectively per square foot of grate per hour, there is evidently room left for more power. The gain in speed which would follow such increase of power is, however, not very great, as is clearly apparent from the results of the last two trials, and still more from the I. H. P. Curve, shown on Fig. 2 (Plate VII), of which something will be said hereafter.

A very good performance was that obtained on the sixth trial (April 28), when, with only two-thirds of the boilers at work, the engines developed over 12,000 I. H. P. (two-thirds of the total power), driving the ship at nearly 17 knots. The cut-off being at 0.175 of the stroke, the steam worked with a ratio of expansion 4.35, which, from the consumption of water shown by the indicator cards, appears to give the most efficient performance of the engines at great power.

A circumstance deserving notice is that all these trials were carried out with the ship's stokers, who, for the greater part, were not yet trained for forced draught stoking.

Regarding the efficiency of the engines, although the consumption of coal was the lowest on the first trial, when the two after engines were acting compound at very low power with a great ratio of expansion (about 11), this condition of working does not appear to be the most efficient, as the consumption of water shown by the indicator cards was greater on this trial than on the next, when the ratio of expansion was reduced to 3.5 only.

The same thing happens, although in a less marked degree, when the engines act with direct expansion, as there is no material difference in the consumption of steam over four expansions. Below this ratio the consumption increases, as may be seen from the results of the last two trials.

To have more complete data of the ship and engines' performance, besides the trials above mentioned, runs were made on the measured mile to ascertain the speed of the ship corresponding to the lowest possible speed and power of the engines; also the power and speed of the engines for a speed of about 10 knots of the ship.

The results are as follows:

Speed of ship, ...	knots,	2.7	10
Revolutions, ...		15	55
I. H. P.		158.6	2403

Now I beg to call attention to Fig. 2 (Plate VII), in which the results relating to the ship's performance are graphically recorded, in connection with the E. H. P. Curve, as was determined by experiments on the model of the Italia made for the Royal Italian Government by Mr. R. E. Froude at Torquay, by the kind permission of the Admiralty.

The E. H. P. curve *aa* corresponds to a displacement of 14,784 tons, which is approximately the mean displacement of the Lepanto at the various trials. The Lepanto being a finer ship than the Italia for the same displacement, the ordinates of curve *aa* should be lowered a little, but considering that the bottom of the Lepanto was not perfectly clean, curve *aa* may be accepted as sufficiently correct.

bb is the I. H. P. curve.

dd is the "indicated thrust curve," as it results from the I. H. P. curve. The dotted line at the bottom of curve *dd* is to show the increase of thrust due to the friction of the forward set of engines when they were acting at low powers with the after set.

According to this curve the initial friction of the engine would be about 7.5 per cent of the load at full power.

ff is the "curve of the net resistance of the ship" as it results from the E. H. P. curve.

It will be noticed that undulation characteristic of the E. H. P. curve *aa* and of the net resistance curve *ff* at about 16.5 knots is faithfully reproduced on the I. H. P. curve *bb* and on the indicated thrust curve *dd*, giving strong evidence of the correctness and importance of the method of investigation devised by the late Mr. Froude.

Curve *cc* gives the ratio $\frac{E.H.P.}{I.H.P.} = p$, viz., the propulsive coefficient or the "net total efficiency of propulsion," which slightly increases at the higher speeds when it approaches to the standard value 0.50.

Curves *mm* and *nn* give the "coefficient of performance" for displacement and midship section.

Curve *gg* gives the ratio between the net resistance of the ship and the indicated thrust.

Curve *hh* gives a similar ratio when the initial friction of the engines is taken off from the indicated thrust.

All these coefficient curves *cc*, *mm*, *nn*, *gg*, *hh*, show more or less an undulation at about the same speed at which there is a marked change on the curve of E. H. P.

Curve *rr* in Fig. 3 (Plate VII) gives the I. H. P. in function of revolutions.

By the following method of investigation devised by Mr. R. E. Froude, and illustrated in his paper "On the Determination of Dimensions for Screw Propellers," read at the Institution of Naval Architects, 1886, I have approximately determined for the maximum speed of 18.38 knots the efficiency of the Lepanto's screw propellers, which would have an abscissa-value 10.75, very close to maximum efficiency. This abscissa-value and the corresponding net total efficiency of propulsion are plotted on Fig. 4 (Plate VI), which is the reproduction of Mr. Froude's standard curve for the efficiency of screw propellers, as illustrated in his paper above mentioned.

With this abscissa-value the true slip of the Lepanto's screw propellers at the speed of 18.38 knots would be about 20 per cent, while the apparent slip is only 2½ per cent, leaving 17.28 per cent for the speed of the wake that follows the ship.

APPENDIX.

To comply with the wish expressed by Mr. F. C. Marshall in his remarks, I have given in Fig. 5 mean specimens of the Lepanto's indicator cards taken during the last three trials.

Regarding the performance of the Flavio Gioja's locomotive boilers, which was not so satisfactory as in the case of the Lepanto, it is necessary to bear in mind that the boilers worked under very different conditions in the two ships, especially on account of the different type of the engines. The Flavio Gioja having trunk engines, the cylinder condensation of steam was much larger than in the Lepanto, with the consequence that the boilers of the Flavio Gioja had to be overworked to give out the required power. This fact goes far enough to account for the difference in the results of the two ships, but some collateral circumstances came also into play, as for instance the less roomy and less comfortable condition of the Flavio Gioja's stokeholds, which prevented the boilers being so regularly and properly worked as in the Lepanto.

On the official trials, the engines of Flavio Gioja developed a mean of 4156 I. H. P., at the rate 14.35 I. H. P. per square foot of grate, with a consumption of seven tons of coal per hour, viz., at the rate of 55 pounds of coal per square foot of grate; the cut-off in the cylinders being 0.35, corresponding to a ratio of expansion 2.33. The consumption of steam, as shown by the indicator card, was about 23 pounds per I. H. P. per hour, viz. 10 per cent larger than that of the Lepanto for the same output of power per square foot of grate.

PARTICULARS OF TRIALS.

	1 April 4.	2 April 7.	3 April 11.	4 April 14.	5 April 28.	6 April 28.	7 May 5.	8 May 12.
Sea	Calm.	Calm.	Rather rough	Calm.	Heavy cross	Calm.	Rather rough	Calm.
Wind	Light N. W.	Light N. W.	Fresh N. W.	Light N. W.	Light S. W.	Light N.	Fresh N.	Light N.
Mean draught, feet	30′ 4″	30′ 4″	30′ 3″	30′ 3″	30′ 1½″	30′ ½″	30′ 3″	30′ 4″
Area of midship section, square feet	1 999	1,999	1,993	1,993	1,984	1,978	1,993	1,999
Displacement, tons	14,860	14,860	14,810	14,810	14,740	14,690	14,810	14,860
Wetted surface, square feet	36,500	36,500	36,430	36,430	36,325	36,255	36,430	36,500
Mean speed of ship, knots	7.25	13.7	13.3	14.4	15.89	16.78	18.18	18.38
Indicated horse power	1,004	6,230	5,714	7,385	10,330	12,010	15,260	16,150
Number of boilers used	2 Oval	8 Oval	8 Oval	4 Oval 8 Locom.	8 Oval 8 Locom.	8 Oval 8 Locom.	8 Oval 16 Locom.	8 Oval 16 Locom.
Number of engines used	2	4	4	2	4	4	4	4
Mode of action of engines	Compound	Compound	Direct	Direct	Direct	Direct	Direct	Direct
Area of fire grate used, square feet	94.1	478 4	478.4	Oval 239.2 Locom. 337.6	Oval 478.4 Locom. 337.6	Oval 478.4 Locom. 337.6	Oval 478.4 Locom. 675.2	Oval 478.4 Locom. 675.2
Heating surface used — Tubes.	3.488	13,952	13,952	18,896	25,872	25,872	37,792	37,792
Heating surface used — Total.	3,840	15,360	15,360	21,040	28,720	28,720	42,080	42,080
Mean steam pressure in lbs. per square inch — Oval boilers.	50	54	37	52	48	51	53.5	54.2
Mean steam pressure in lbs. per square inch — Locom. “	..	..	..	58	52	56	58.5	60.
Mean steam pressure in lbs. per square inch — Engine room.	48	51	34	47	44	47	49.	49.
Mean air pressure in inches of water — Oval boiler stoke holes.	Natural	0″.65	0″.94	1″.	1″.	1″.5	1″.	1″.6
Mean air pressure in inches of water — Locom. “ “ “	..	..	..	1″.9	1″.2	2″.5	2″.	1″.9
Cut off — In H. P. cylinders.	0.1	0.5	0.1	0 45	0.175	0.175	0.3	0.3
Cut off — “ L. P. “	0 6	0.6	..	..	..	..	..	..
Ratio of expansion	11.1	3.5	5.56	1.89	3.93	3.93	2.63	2.63
Mean pressure in lbs. per square inch — H. P. cylinders.	15.3	23.	15.4	36.62	23.5	26.1	30.65	31.9
Mean pressure in lbs. per square inch — L. P. “	6 8	13.	..	..	..	..	..	..
Mean vacuum in condensers, inches	28.6	28.7	28.6	27.	27.5	27.5	27.	27.
Revolutions per minute	38.8	70.53	68.73	74.25	80 95	85.	92.05	93.5
Apparent mean slip, per cent	6.4	4.25	4.6	3.8	2.7	1.8	2.34	2.72
Mean speed of piston per minute, feet	252.2	458.25	445.25	484.27	526.5	552.5	598.	607.75
I. H. P. per square feet of grate	10.7	13.	11.9	12.8	12.6	14.6	13.1	14.
Heating surface per I. H. P., in square feet — Tubes.	3.48	2.24	2.45	2.55	2.5	2.17	2.46	2.34
Heating surface per I. H. P., in square feet — Total.	3.82	2.47	2.69	2.84	2.78	2.41	2.74	2.61
Coal used per hour, in tons	0.9	6.4	6.9	11.4	13.7	16.8	21.8	23.5
Coal used per I. H. P. per hour, in lbs.	2.02	2.27	2.75	3.45	2.97	3.14	3.2	3.3
Coal burnt per square feet of grate per hour — Oval boilers, lbs.	21.3	29.9	32.3	34.	35.	38.	33.	38.
Coal burnt per square feet of grate per hour — Locom. “ “	..	..	..	51.	41.	58.	49.	51.
Steam used per I. H. P. per hour as shown by indicator cards	16.1	15.	18.2	22.2	18.4	18.2	21.1	20.7

Scale of Efficiency
and Value of $\frac{E.H.P.}{I.H.P.}$

PARTICULARS OF TRIALS.

		1 April 4.	2 April 7.	3 April 11.	4 April 14.	5 April 28.	6 April 28.	7 May 5.	8 May 12.
Sea		Calm.	Calm.	Rather rough	Calm.	Heavy cross	Calm.	Rather rough	Calm.
Wind		Light N. W.	Light N. W.	Fresh N. W.	Light N. W.	Light S. W.	Light N.	Fresh N.	Light N.
Mean draught, feet		30′ 4″	30′ 4″	30′ 3″	30′ 3″	30′ 1½″	30′ ½″	30′ 3″	30′ 4″
Area of midship section, square feet		1 999	1,999	1,993	1,993	1,984	1,978	1,993	1,999
Displacement, tons		14,860	14,860	14,810	14,810	14,740	14,690	14,810	14,860
Wetted surface, square feet		36,500	36,500	36,430	36,430	36,325	36,255	36,430	36,500
Mean speed of ship, knots		7.25	13.7	13.3	14.4	15.89	16.78	18.18	18.38
Indicated horse power		1,004	6,230	5,714	7,385	10,330	12,010	15,260	16,150
Number of boilers used		2 Oval	8 Oval	8 Oval	4 Oval 8 Locom.	8 Oval 8 Locom.	8 Oval 8 Locom.	8 Oval 16 Locom.	8 Oval 16 Locom.
Number of engines used		2	4	4	2	4	4	4	4
Mode of action of engines		Compound	Compound	Direct	Direct	Direct	Direct	Direct	Direct
Area of fire grate used, square feet		94.1	478 4	478.4	Oval 239.2 Locom. 337.6	Oval 478.4 Locom. 337.6	Oval 478.4 Locom. 337.6	Oval 478.4 Locom. 675.2	Oval 478.4 Locom. 675.2
Heating surface used	Tubes.	3.488	13,952	13,952	18,896	25,872	25,872	37,792	37,792
	Total.	3,840	15,360	15,360	21,040	28,720	28,720	42,080	42,080
Mean steam pressure in lbs. per square inch.	Oval boilers.	50	54	37	52	48	51	53.5	54.2
	Locom. "	..	..	..	58	52	56	58.5	60.
	Engine room.	48	51	34	47	44	47	49.	49.
Mean air pressure in inches of water.	Oval boiler stoke holes.	Natural	0″.65	0″.94	1″.	1″.	1″.5	1″.	1″.6
	Locom. " " "	..	..	..	1″ 9	1″.2	2″.5	2″.	1″.9
Cut off	In H. P. cylinders.	0.1	0.5	0.1	0 45	0.175	0.175	0.3	0.3
	" L. P. "	0 6	0.6	..	..	..	..	..	..
Ratio of expansion		11.1	3.5	5.56	1.89	3.93	3.93	2.63	2.63
Mean pressure in lbs. per square inch	H. P. cylinders.	15.3	23.	15.4	36.62	23.5	26.1	30.65	31.9
	L. P. "	6 8	13.	..	..	..	..	..	..
Mean vacuum in condensers, inches		28.6	28.7	28.6	27.	27.5	27.5	27.	27.
Revolutions per minute		38.8	70.53	68.73	74.25	80 95	85.	92.05	93.5
Apparent mean slip, per cent		6.4	4.25	4.6	3.8	2.7	1.8	2.34	2.72
Mean speed of piston per minute, feet		252.2	458.25	445.25	484.27	526.5	552.5	598.	607.75
I. H. P. per square feet of grate		10.7	13.	11.9	12.8	12.6	14.6	13.1	14.
Heating surface per I. H. P., in square feet	Tubes.	3.48	2.24	2.45	2.55	2.5	2.17	2.46	2.34
	Total.	3.82	2.47	2.69	2.84	2.78	2.41	2.74	2.61
Coal used per hour, in tons		0.9	6.4	6.9	11.4	13.7	16.8	21.8	23.5
Coal used per I. H. P per hour, in lbs.		2.02	2.27	2.75	3.45	2 97	3.14	3.2	3.3
Coal burnt per square feet of grate per hour.	Oval boilers, lbs.	21.3	29.9	32.3	34.	35.	38.	33.	38.
	Locom. " "	..	..	..	51.	41.	58.	49.	51.
Steam used per I. H. P. per hour as shown by indicator cards		16.1	15.	18.2	22.2	18.4	18.2	21.1	20.7

FIG. 1

Arrangement of Engines and Boilers.

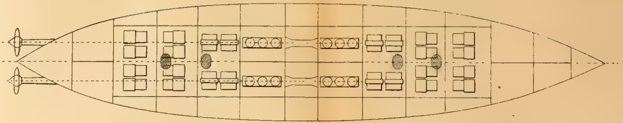
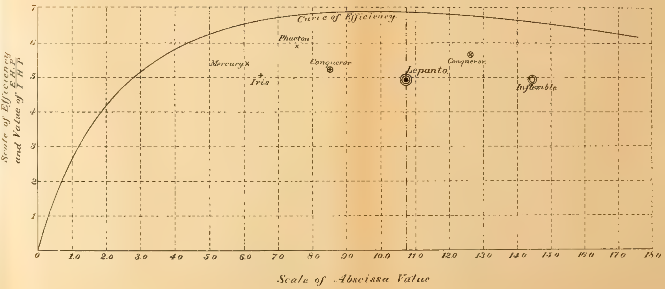


FIG. 4.



0
5
10

FIG. 2.

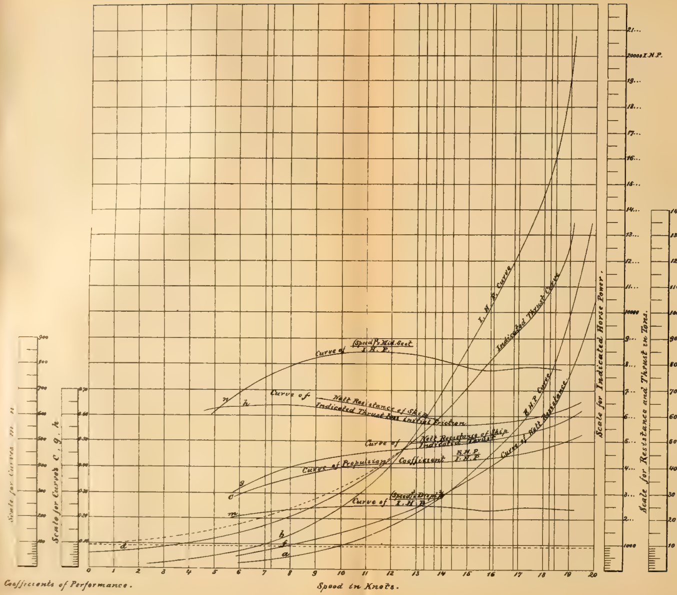

Scale for Curves m n
900
800
700
600
500
400
300
200
100
Scale for Curves C, g, h
0.70
0.60
0.50
0.40
0.30
0.20
0.10
Curve of (Speed)³ × Mid. Sect / I. H. P.
Curve of Nett Resistance of Ship / Indicated Thrust less Initial Friction
Curve of Nett Resistance of Ship / Indicated Thrust
Curve of Propulsion Coefficient E.H.P. / I.H.P.
Curve of (Speed)³ × Displ.⅔ / I. H. P.
I. H. P. Curve
Indicated Thrust Curve
E.H.P. Curve
Curve of Nett Resistance
n
h
g
c
m
d
b
f
a
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
Speed in Knots.
Coefficients of Performance.
Scale for Indicated Horse Power.
21...
20000 I.H.P.
19...
18...
17...
16...
15...
14...
13...
12...
11...
10000
9...
8...
7...
6...
5...
4...
3...
2...
1000
Scale for Resistance and Thrust in Tons.
140 Tons
130
120
110
100
90
80
70
60
50
40
30
20
10

FIG. 3.

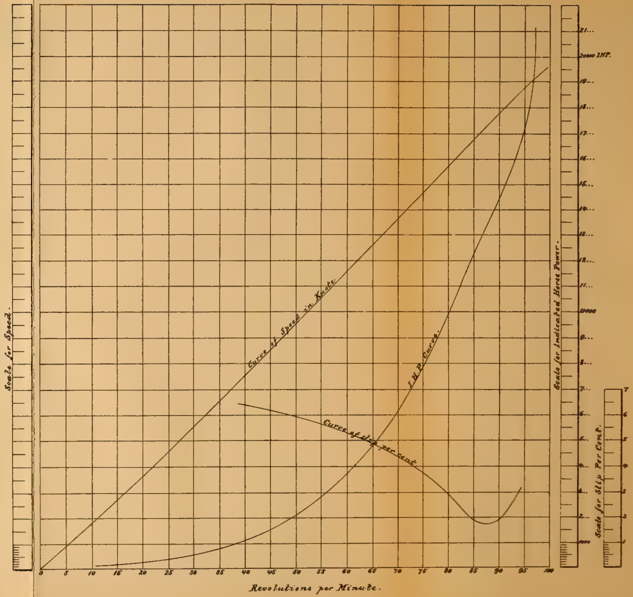
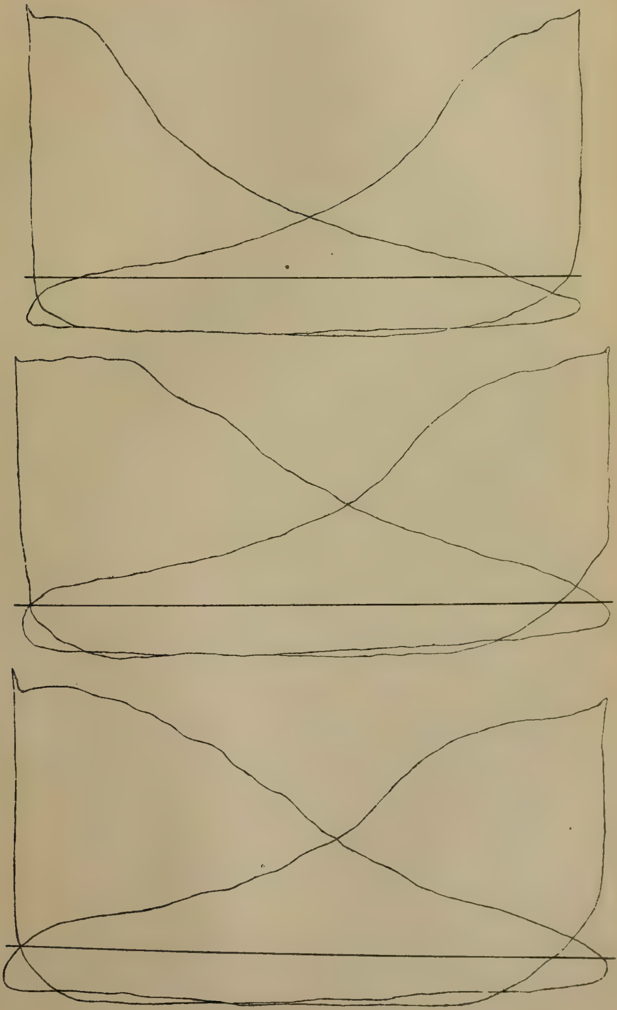

Scale for Speed.
Curve of Speed in Knots.
I.H.P. Curve.
Curve of slip per cent.
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
Revolutions per Minute.
Scale for Indicated Horse Power.
21...
20000 I.H.P.
19...
18...
17...
16...
15...
14...
13...
12...
11...
10000
9...
8...
7...
6...
5...
4...
3...
2...
1000
Scale for Slip Per Cent.
7
6
5
4
3
2
1

FIG. 5.

Average Cards taken during the Trials
Scale $\frac{1}{24}$



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NOTES ON THE MANAGEMENT OF BOATS IN THE SURF.

By A. A. Ackerman, Ensign, U. S. N.

The literature on the subject of surf-boating is so scanty and contains so little practical information outside of a few general rules, that the following notes are presented with the hope that they may be of use to the service, rather as suggesting the need of a comprehensive description of the surf and method of passing it in all parts of the world, than as a manual for any one locality. An examination of all the works on seamanship and boating discloses only a few axioms, so stripped of detail as to be of use only to those well acquainted with all the difficulties likely to be encountered. If one succeeds in following these terse directions he may get ashore dry, but the surf rarely allows time either for reflection or for the application of any but almost instinctive methods. A very large amount of information is in the possession of officers whose opportunities for observation have been good, but it is seldom that surf-boat duty has continued long enough to give the average officer more than a keen appreciation of its uncertainties. These notes are founded on an experience extending over three years on the U. S. S. Ranger: during this time hundreds of landings were made by the officers on the west coast of Lower California and Costa Rica, for the purpose of erecting signals and carrying on the triangulation. In addition, the coast was followed, and its outline and topography fixed for over three hundred miles; information as to the effect of peculiarities of the shore was thus obtained.

Generally speaking, the surf differs almost as much as the other features of the coast. It is modified by currents, outlying rocks, shoals, river bars, the curves of the coast, and the kinds of beach, whether steep to, sloping, rocky, or sandy. Again, it changes every hour of the tide and with every variation in the force and direction of the wind and ocean swell. The way of passing it in each case must differ somewhat if the best results are to be obtained, and so in different localities the surfmen have their own peculiar methods, governed by the character of the surf, the objects sought in passing it, and their equipments.

It is difficult to compare surfs at long intervals of time and at widely distant points, hence the question whether a landing can be safely made or not will frequently be left undecided until the shore is reached. Even then chance may have played so important a part in the operation that the rule may be laid down never to attempt a landing without taking every precaution for safety in case of being capsized.

From the ship, a mile or two off shore, the surf may seem uniform, and opinions may differ as to the best landing place. Patches of sand beach will alternate with bluffs, below which lie rocks and debris, sometimes only shown in the churned-up surf when dangerously near. The débris is often swept by the combined action of the surf and current into the form of an irregular breakwater towards the lee side of the bluff. This shoal being of varying height and lacking continuity, may be of little help when covered by the flood; but at low water its influence is at once apparent. The sand beach begins below this point, back of the face of the bluff, perhaps marking an ancient river mouth, with even now a weak stream seeping through the sand and shingle piled up by storms and surf. This is washed away every time the river rises, leaving a shallow recess in the beach. The best landing may be looked for at such a point. It may even be possible to zigzag in between the bluff shoals and river bar.

For the same reasons narrow cañons in long stretches of bluff sometimes mark quiet spots, but are dangerous on account of the boulders washed down by the streams.

On a long stretch of sand beach it is difficult to make a choice, but it is certain that wherever a shoal appears or the surf stretches far out, there will be found a comparatively light surf on the lee side.

Pockets in a rocky coast sometimes show tempting beaches at their bottom, but should not be entered until carefully inspected. They frequently contain sunken rocks; the surf is treacherous, and the most skilful crew trapped in such a place may find it impossible to avoid disaster.

A single rock, hardly far enough off shore to be shown on the chart as separated from the beach, will frequently have a quiet place in its lee, although the approach to it may be dangerous at times.

A confused surf off the mouth of a lagoon or river, or the slanting breakers which sometimes run along the beach, had better be avoided unless low, as the boat may be filled by cross surf while pointed to receive the main breakers.

The more or less regular recurrence of the heaviest breakers, the point at which they become dangerous by commencing to break, and that at which they become comparatively harmless by falling into confusion, should be considered. A heavy breaker arriving at regular intervals, rising and curling only to fall to pieces, may be dodged, but if it is carried a long distance, the probable effect on the boat in passing it must be taken into account.

The number of lines of breakers or width of surf does not always determine the danger of landing, as the outer lines will be much the heaviest and may frequently be avoided.

Notice should always be taken before entering the surf of the probable drift of the boat; it may be set by the current down among rocks or into heavy surf.

The beach may present obstacles apart from the surf. It is often difficult to climb a steep shingle beach at high water even without being obliged to drag the boat clear of the breakers. At the same place a good landing may be made at low water on the uncovered sand slope below the shingle. A ledge of rock cropping out through the sand beach, or scattered boulders, sometimes endangers the boat's bottom. In such cases there are but two ways of landing. The preferable one is to make the passengers jump and wade ashore the instant the boat touches, hauling out at once through the surf. The second plan is to order everybody out of the boat as soon as a foothold can be secured, to steady and protect it. The first big swell should be utilized to land the boat as high upon the rocks as possible. Often the boat reaches a rocky beach nearly full of water; should it touch a rock while in this condition the consequences would be disastrous. Circumstances must decide whether it is better to paddle and drift along in the inshore surf while the boat is being bailed out, or to hold it in one spot until ready for landing or going out again.

A surf crew, exposed to unusual hardship and danger, constantly wet and frequently losing their meals, deserves great consideration aboard ship. The men must not only be trained to act powerfully together like a racing crew, but each one must quickly recognize the necessity for individual action and perform his part without special orders from the coxswain. No racing crew has more need of utter subservience to their coxswain—obedient at the instant, yet possessing the intelligence necessary for independent action.

Disaster is most certain if the attempt is made to pass heavy surf with inexperienced men; in fact, a single raw hand may jeopardize the whole crew. Sometimes the new man may be dazed and sit quietly without working, which is perhaps best for all hands; others select the critical moment to adjust their trailing lines or foul the oars. Excitable ones may sing out and even try to direct the handling of the boat, so greatly do they feel the need of action. The boat officer should recollect that frequently the coxswain has had much more experience than himself, besides, from his elevated position and feel of the steering oar, he knows better both the position and tendency of the boat. To deprive him of the right to direct momentarily would be to impair his efficiency. Unless the boat officer takes the steering oar himself, he should be content with the selection of the place and time of landing. He will have time often to decide and direct whether to take or run from a breaker, but almost all else will be too quick for anything but the instinctive action of coxswain and crew.

A crew may be gradually trained in light surf. Should they meet with a few harmless capsizes, so much the better, as they will find it not so very terrible after all if they succeed in escaping bruises from the flying oars. Above all, the crew should have confidence in their coxswain and boat officer. Whatever is attempted should be done unflinchingly; vacillation or alarm in either of them will reflect itself instantly in the faces of the crew. The latter, low down and with their backs to the surf, can form no correct idea of their danger. Before entering the surf at a strange locality, it is well to lie off it for awhile, noting its peculiarities and accustoming the crew to them. Dangerous breakers may pass, but the quieter intervals are very encouraging.

The matter of life-boats has been much agitated of late by those interested in the various designs, and though the requirements of a good surf boat differ materially from those of a deep-sea life-boat, yet they are alike in some main particulars. A boat combining in a high degree the qualities of both can be built, the objectionable difrerences being removed or lessened whenever it is used for one or the other purpose. Along shore two life-boats are used, a heavy one, non-sinkable, self-righting and bailing, requiring ways for launching or a harbor from which to start, and a light, non-sinkable, self-righting boat. The former, however satisfactory in making a passage at sea, where its best points are shown, of course could not be handled by its unaided crew on the beach. Its weight, slowness under oars, and large crew are also great objections to its use for ordinary ship work or life-saving at sea, where the handiness of a light boat and small crew has been none too quick to save life on many an occasion. Every one has noticed how much more difficult it is to pick up an object on the water in a moderate sea with a heavy boat and large crew than with a light boat and small crew. The light surf boat, depending more upon the dexterity of its crew to avoid danger, still possesses no mean power of its own through sheer and buoyancy to keep the water out.

A life-boat's crew, though composed of picked men, have but little power compared with the forces against which they are sometimes obliged to contend. Though their boat may be self-righting, self-bailing, etc., so long as it is not self-propelling and self-directing, its weight must be kept down and handiness in steering made a prominent characteristic. Without these latter qualities the former are made absolutely necessary, for though the boat will doubtless perform its righting and bailing functions with clock-like precision, it is unable to avoid danger. Its destination is reached only after the expenditure of an enormous amount of labor and much precious time.

The qualities of a surf boat should include :—

1. *Great sheer, with upper strakes flaring at bow and stern*, to keep out as much of the crest of a passing breaker as possible, to support the boat when lifted by a wave, and to prevent the ends dipping under when sliding down a wave. For the same purposes, and to assist both bow and stern in buoyancy and consequent quick movement in answer to rising waves, weights should be kept out of the extreme ends of the boats.

2. *The submerged part of the boat should offer the least possible resistance to turning*. A wave, in broaching a boat to, acts on all parts of it similar to fixed rudders, keel, forefoot, run, and side. To resist this the coxswain relies upon the leverage of his steering oar. If the bottom of the boat is rounded and smoothed off in every

direction, regardless of arbitrary rules of beauty or dismal prophecies, a type is obtained on which the water has the least hold for turning and the coxswain the greatest for directing. It will be almost a miracle if a heavy keel boat, once slightly turned and being carried back on the face of a breaker, can be righted unless the crew is well trained and succeed in holding it until the breaker slips under. The critical period with a keel boat in such a case is extremely short, for it catches at once on the under dead-water and trips as it is carried back until the gunwale dips under and the boat capsizes. A very light, smooth-bottomed boat, however, is sometimes swept along before the breaker without capsizing. An incident comes to mind in which this fact is clearly illustrated. A man was sent ashore from the Ranger one day in the dory; mistaking his orders, he pulled directly for a party on the beach instead of the usual landing place. It was high tide and the surf was very heavy, so heavy that on reaching the outer line of breakers he gave up his purpose, and was about returning to the ship, when a very large breaker, combing over farther out than usual, gave the boat such a spin that the man tumbled off his thwart. Before he recovered himself the boat almost stood on end on the side of another swell, and an instant later was inside the line of breakers. The man struggled vainly to rise; he no sooner sat up and groped for his oars than the boat, dancing about like a cork, threw him down again. It darted in one direction at some wave's impetus, then being caught again was spun around and sent off in another whirling and zigzagging. In this manner the boat came rapidly in, coquetting with the breakers, yet never caught and held. Near the shore the surf was lighter, and several breakers passed, each causing it to ship a few pints of water. The man landed almost dry. This dory was about fifteen feet long, with high bow and stern, considerable flare, and gave no more resistance to lateral motion in the water than the well-inclined smooth sides offered. It was impossible to pin it down with side pressure, as it evaded it by motion in direction of its length.

The upper bow should be quite sharp, though not lean, to part the breaker after the boat has risen as far as possible, rather than oppose a flat resisting surface, tending to throw it back.

3. *High freeboard, high, roomy thwarts, and favorable positions for oarsmen and coxswain in which to exert their strength.* No one who has seen the crew of a navy whaleboat struggling in a moderate sea but has condemned for all such work low, cramped thwarts,

crowded in the bow of the boat, and eighteen-foot oars inserted in rowlocks that clash and lose power on the back strokes. Swivel rowlocks should always be used when there is so great a chance of fouling the oars. The thwarts and rowlocks may be arranged so as to be shifted according to the duty; the lines of the boat should be such, however, that its speed and turning power is at its best when arranged for the surf. Then its propelling power should be nearly equally spaced about its centre of buoyancy, the thwarts three feet apart, the oars light and stiff. Passengers must stow themselves between the thwarts in the bottom of the boat. They should not be permitted to incommode the oarsmen, crowd the stern or foresheets, or sit upon the gunwale. The coxswain should have a platform sufficiently large to permit him to brace himself and use his strength freely on the steering oar. This should be broad, stiff, and not too long.

In most navy boats one-third, if not more, of the boat is taken up by the stern sheets, in which the cargo is carried. Of course, this load must always bear a certain relation to the weight of the crew, or the boat will not have her proper lines, being down at the head or at the stern, or in some one or more ways unfit for rough weather. To remove these objectionable features a radical departure must be made in the case of the surf boat. The cargo must be subordinated to the means of transportation, and so distributed as to increase the stability. The sides should be high enough not to take in water at every little roll or splash, and permit the crew to use their oars even when on the side of a wave. On troubled water, be it at sea or in the surf, a long oar is a nuisance. It cannot be handled quickly, it wears the men out, and in all its low length it is certain to strike on the back stroke, neutralizing its effect. If in addition it is springy, by the time the power is well applied in one direction the boat is turned or tilted and most of the stroke lost. The coxswain, too, is frequently loaded down with an oar, which, though excellent as a rudder, when the boat is pulled rapidly, must, when in the surf or moving slowly against a sea, be used as a lever for prying the stern around. It is evident, therefore, that we are reducing the coxswain's effective strength for steering by every foot we put upon the blade beyond a certain point. At that point, the water being supposed immovable, he exerts the greatest effort on the stern rowlock, when standing on his platform. The size of the blade and length of the oar should therefore vary with every change in the height of the stern.

4. *Lightness.* As a rule, navy-built boats are not sufficiently light for surf work or for any protracted pull in a seaway. The lighter and more buoyant the boat, the more facile its obedience to every impulse of the waves and oars, and herein lies much of its safety. Instead of crashing through or taking aboard waves as a heavier boat would, it rises nimbly over or slips around them, taking in little or no water. In landing or launching, the crew can handle it easily, dragging it quickly up stony beaches out of the reach of the surf. Above all, in a light boat the ratio of the weight moved to the power of the crew is less than in the case of the heavy one; and nowhere is this more evidently advantageous than in the ease with which the coxswain can direct it or the crew steady it on the dangerous side of a breaker.

5. *Strength* should not be obtained at the expense of lightness or any other desirable quality. It should be that of selected material and studied construction rather than of mere bulk. A surf boat is required to stand the shock of landing when full of water on bilge, stern, or forefoot, or on its gunwale when upside down, without opening its seams. It should stand the jar of a fall into the trough of the sea when sent at a good speed through a wave-crest, and support the rowlocks and thwarts with the men exerting their utmost strength. A towing post should be placed in the bow for veering surf line, and which may therefore be suddenly required to take the weight of the boat and its crew.

6. *Buoyancy.* Besides possessing natural buoyancy due to lightness, it should be fitted with air tanks, in bow and stern and along the sides under the thwarts, sufficiently large to support the boat full of water, crew, and cargo. An extreme type of surf boat would be similar to the Esquimau's kayak, in which there would be no room for water after the crew had taken their seats, all vacant spaces being filled up with tanks. A proper adjustment of the air tanks will render the boat self-righting; though that is of less importance in the surf, unless it is very wide and low. A crew once demoralized by being capsized, will hardly be able to regain control over their boat before it has drifted into the beach.

7. *Size and crew.* The larger the boat, if equally well handled, the less the effect of the breakers either for filling or capsizing it. On the other hand, a large boat is more difficult to handle. It requires more trained men; and the likelihood is not great that a crew will be preserved intact, despite sickness or other duty. Few ships

would be able to man a double-banked boat with surfmen. A single-banked, six-oared whaleboat may be taken as the economical type in which the best proportion of skilled power to resistance is likely to be obtained.

Even in combining the qualities required in a surf boat, it will be found that many concessions must be made. If in addition it is required to possess all the varied qualities of a ship's boat, or, in fact, any one of them seriously conflicting with its special purpose, the result cannot be satisfactory. The *combination* has failed; the surf boat, if it is given a fair trial, must be something more than that in name. The mean between pleasure and cargo-carrying craft, built, it would seem, merely to exercise as many men as possible, with little or no thought of the possibility of rough weather, should not be taken as the standard ship's boat. If a surf or life-boat is required to conform to them in almost any particular, it will do so only by the sacrifice of important characteristics. On the other hand, their functions can be performed by the latter; in many respects more efficiently. Great sheer and freeboard are undoubtedly serious objections in pulling or sailing to windward, but they may be mitigated by using removable washboards and ballasting the boat, while a side board may to a degree take the place of an external keel.

A description of the passage of heavy surf, using a one-hundred-and-fifty-fathom whale-line and ninety-pound kedge, will best show some of the difficulties encountered, especially those likely to arise from the use of a long line. All unnecessary articles are taken out of the boat. The water breaker is tightly plugged and lashed down, as are all stretchers and two buckets for bailing. The men shift into light clothes without shoes. If the weather is sufficiently cold to require it, dry clothing may be carried in the air tanks, which should, however, be carefully inspected and all unnecessary articles removed. A hatchet, copper tacks, sheet lead, and a roll of felting should also be carried for use in case the boat is stove. If the beach is distant, it is well to go under sail, so as to keep the men fresh, buoying the sails and spars over the anchor outside the surf.

After carefully inspecting the surf and beach, the landing place is finally selected. Perhaps it is an open, flat, sand beach, on which the breakers are rolling in heavily every few seconds. The question now arises, How far out will the surf line permit the anchor to be dropped? If let go just outside the breakers, it may be necessary to pick it up in them when coming out, through its having dragged, the tide having fallen, or the swell increased. The anchor should be dropped far out, in order to give it plenty of room in which to drag. Moreover, as the coast current will sweep the boat down until the line tends over the bow, the longer it is for the same width of surf, the less angle will it make with the proper direction of the boat normal to the breakers. Having dropped the anchor, being careful to have it stocked, take in the bow oar, buoy sails, and pull in close to the outer breaker, turning around and heading out.

It is an open question whether any advantage is to be gained by making the after-oarsmen turn round on their thwarts. It is confusing, takes them from under the influence of the coxswain's eye, and, by making them face the surf, distracts their attention from the orders given behind their backs. In an expert crew, each man knowing his duty and performing it without special instructions, the advantages are all the other way; still, but few expert crews will be met with in the service.

On the verge of the breakers the bow oar hauls taut the surf line and sees it clear for running. The crew rests with oars apeak, the coxswain paddling gently to keep the boat headed out, waiting for the quiet spell that generally follows heavy breakers. Finally the heavy swells come rolling in, perhaps three of them, the second combing over just in rear of the boat. Veer as much as possible consistent with safety. To seaward all seems smooth outside the third breaker now speeding in. Its top grows sharper, and as it lifts and hastens, all along its lurching front is heard the seething of the spray. It strikes; the boat lifts to it, and almost at that instant its crest curves downward in a rounded sheet of falling water with a thundering crash. "Slack!" "Stern all!" and the boat flies in, the surf line humming out, and the men straining at the oars to preserve their position on the back of the wave. Ten seconds of this ride, and the friction of line and boat has retarded it sufficiently to let the breaker get away, but the long stretch of surf line on the foam-covered water behind is an encouraging evidence of the dangerous space passed. Now comes the crew's greatest need of experience and strength. Every effort is put forth to urge the boat in as far as possible before it is struck by the next breaker. Fragmentary and spontaneous breakers rise up in the troubled water, dividing or consolidating with others. In encounters with these the boat perhaps takes in a great deal of water. The surf line, nine-tenths of the time useless, retards continually. The boat has drifted down until the anchor is on the bow, and the great bight in the line, paid out to hasten progress, shows that it can no longer be depended on. Now and then in the froth a great breaker gathers, and the question arises whether by pulling out it can be reached before cresting over, or by backing in hard the boat can be kept ahead until it falls. In either case the decision must be made quickly. Perhaps it cannot be avoided; the instant before it reaches the boat the order is given, "Hold water!" "Peak!" The bow oarsman having, if possible, hauled in the slack of the surf line, takes two turns and lies back. The men crouch, throwing their oar-blades high in the air; the coxswain steers to the last, but the instant the breaker is on him also crouches, lifting his oar as far out of the water as possible.

The breaker falls, and in a moment the seething foam and water is rushing by, seemingly high above the gunwale. The boat has cut off the top of the breaker and is half full of water. The bow oar has been thrown on his face by the weight of falling water and upward lift of the boat. It may be that the shock is so great that some of the crew are flung into the stern sheets. If the line is taut and the anchor holds, the breaker passes on, leaving the boat demoralized, but still able to hold its own in the lighter surf. A bight in the line is fatal; the boat moves bodily to the rear in the tumbling water, slowly turning and canting. But the instant the breaker falls, the oars can be used, and unless the water-logged boat is too sluggish, it is again brought head to sea. Stern all again, the passengers bail. Breaker after breaker passes until swirling eddies and light cross surf are met close to the beach. Each breaker has left its quota of water, and it may now be up to the thwarts, with the current setting the boat down the beach at a rapid rate. In this condition it is easily capsized if not landed end on and at once steadied by the crew. On touching bottom all hands peak oars, sliding the looms under the opposite rails to hold them clear of the water, and jump overboard, running the lightened boat up on the beach. Stray oars may injure some one or be snapped under the bilge: it takes too long to get them in the boat, but they can be instantly secured out of the way by peaking.

It is very important that the oars should be lifted clear of the water when the boat is struck by a breaker. It is impossible, even with a taut surf line, to prevent the boat springing back a little under the shock, when, if the oars are in the dead-water, they are almost certain to fling the crew on their faces and the coxswain overboard. At that time oars are of no use; if the boat is not head on it is too late. It is impossible to row up such a perpendicular wall of water; but the instant the boat is lifted, whether it is being carried along or not, every available oar should be employed to direct it.

In going out, the time of start, though important, is less so than when coming in, as it may be possible to pull half way out without fear of meeting dangerous surf. If a surf line is used, take the boat up the beach until it appears that when carried down by the current and hauled out at the same time it will reach the dangerous space with the line fair to the anchor. Station two active, powerful men to haul in the line, as more progress will be made in this way than if they took oars. The four after-oarsmen steady the boat, standing in the water opposite their thwarts, oars apeak. Put the passengers aboard, haul taut the line, and commence walking out the boat, the coxswain at the stern. As soon as the boat leaves the bottom the men climb in and take their oars, pointing them to prevent drift until ready to start. The intention is so to time the arrival of the boat at the outer line that no heavy breakers will be met at that point. Varying width of surf and speed of boat makes this difficult of attainment.

At the start the men pulling and hauling force the boat rapidly through the water. Irregular waves splash into the boat; later they become too large to be pulled through without taking much water aboard. It is then best to check headway, tauten the line, and peak oars as the breaker passes. So the boat works out, obviously passing many more breakers than when coming in. Gradually the filling boat becomes sluggish, difficult to pull and steer. In this condition it is almost certain to be capsized if slightly turned. The admirable buoyancy and quickness is gone; it scarcely rises to the swell, but dumbly takes every swash aboard. Or, suppose while still in the midst of the surf the current has swept the boat below the anchor. The line now tends over the bow and can no longer be used; indeed, it is a source of danger, its bight tending to turn the boat even when allowed to drag freely.

It is now better to go back, bail out, and try again, than to struggle on and risk an almost certain capsize in the heavier breakers. The idea is prevalent that to pass a breaker it is necessary to charge it. That is the safest policy only before or at the instant the swell breaks, or in case a breaker is so light that it is certain the boat will ride it. A properly pointed boat will suffer less disorganization if permitted to await a heavy breaker which it cannot hope to ride, than if it is rammed into it. In either case the crest will fall into the boat, which will be swept back some distance.

With men who can swim, and a good buoyant boat, a capsize is not necessarily a dangerous accident unless it occurs far out, in very heavy surf, or when the surf line is used. The latter is always a danger in going out. Suppose the boat has reached the outer line of breakers into which the anchor has dragged: owing to the current it is impossible to strike it fairly, and the line will have to be underrun, seriously exposing the boat for some moments. Caught in this predicament, it may be necessary to cut the line in order to get out. Or, suppose just at the last moment the boat capsizes, with one hundred and fifty fathoms of surf line loosely coiled in the bow and a couple of turns around the towing post. Bights fall through one another, and after the rolling boat has been swept in twenty to fifty fathoms, an immense knot forms somewhere under the surface, holding it in heavy surf. The men right the boat again and again, endeavoring to free the line, but their strength becoming exhausted, one after another is torn away and swept on toward the beach—lucky indeed if they succeed in reaching it. In such a case the line should be cut at once; the possibility of clearing it may be discussed afterward. A *buoyant* boat will come in to the beach with the crew hanging on almost as fast as the breakers.

There are occasions when a surf line may be absolutely necessary, as when veering in a heavy boat; but it always creates special difficulties and dangers. It pulls the bow down when rising to a heavy swell, and if the sheer is great, tends to capsize it around its longer axis. Though excellent for a few seconds when going ashore, after that it is a nuisance, cumbering the boat and increasing its weight. A knife or hatchet should always be at hand, ready to cut it in case it jams, the boat capsizes, or it is necessary to abandon the anchor.

Many of these objections apply to the drogue, which, though useful to *steady* sail and rowboats moving rapidly in a wide but moderate surf, is not of much account when the surf is narrow and heavy. This is because its resistance, increasing only with motion, does not accumulate until the boat has been carried back and perhaps capsized. The ability to trip renders it unnecessary to carry a very long line, but then it is necessary to drag it after the boat when inverted.

Surf is dangerous, according to the boat and crew, when it is able to sweep the former back on its face in spite of the efforts of the latter. With a smooth-bottomed boat and skilful manœuvring it may be possible to escape capsizing, but at such a time nothing can take the place of a surf line and well-bedded anchor.

PROFESSIONAL NOTES.

West Point, N. Y., *September* 6, 1889.

To the Secretary U. S. Naval Institute,
Annapolis, Md.

Sir:—Captain W. T. Sampson, in his excellent article on the Naval Defense of the Coast, published in the July issue of the Proceedings of the Naval Institute, takes occasion to depart somewhat from the strict limits of his subject, to explain why the Board on Fortifications and Other Defenses did not provide for the defense of the eastern entrance to Long Island Sound at the Race by forts. In making this excursion from the main line of his argument, the Captain has unintentionally misstated a paper read by myself before the Military Service Institution, and, in consequence of this error on his part, I am prompted to ask permission to make the proper correction.

The portion of Captain Sampson's paper to which I refer is the following: "A paper read before the United States Military Institution criticises the 'Board on Fortifications and Other Defenses' for not defending this passage [the Race] and thus protecting all points within the Sound, including New York itself. The Board was of the opinion that an enemy could not be stopped at the Race by fortifications, and, as the Board was organized to make practical recommendations, I think it wisely placed the defenses where they were confident the enemy could be stopped [at Throgg's Neck].

"The recommendations of the Board did not present the beautiful simplicity of the plan in the paper above referred to, in which 20-inch guns are advocated for each side of the Race."

I pass by in good humor the doubtful compliment ensconced within the passage quoted, and beg simply to say, purely by way of correction, that the paper referred to did not advocate 20-inch guns for the defense of the Race. It did state that, in the judgment of the writer, the Race could be defended from the shore, and, since the publication of the paper, this has been confirmed by the statement of one of the best practical military engineers of our country, after a personal inspection of the point. A reference to page 181 of the paper as published will show that the writer considered guns of no larger caliber than 17.5 inches to have sufficient power to close the Race against anything carrying 20 inches of steel armor, or its equivalent, or less.

If the quotation means to imply that it is impracticable to mount guns as large as 20 inches caliber at important points on our coast, I am in position to answer that I have accurate information that at least one firm of gunmakers (Krupp) can produce guns of this size, and so good an authority as Gen. Abbot advocates "the largest possible gun" for coast defense.

Captain Sampson makes another error in treating of this matter, to which attention should be called. He assumes that the Race can only be defended by forts from Fisher's and Gull Islands. In this he has clearly overlooked the fact that Valiant and Race Rocks stand in the interval between these islands and offer typical sites for turret forts. If these rocks be occupied, the range would be reduced to one half that given by Captain Sampson, or to such as would require a hostile vessel to run within one mile of the guns of the forts. It must be admitted that better conditions than this for land defense cannot reasonably be asked for.

It is a difficult matter to fix in a definite way what amount of defense, whether land or water, will "stop" and what will not "stop" an enemy, but it may be accepted as a fact that if this point were fortified as proposed, no ship could pass in through the Race without being exposed to fort fire at point-blank range, and to a thoroughly effective fire for some time before and after passing through the Race.

In reference to the point made that the enemy's man-of-war might make a sudden dash through the Race under cover of fog or darkness, since, on account of the swiftness of the current, torpedoes cannot be planted, it may be said in reply that the waterway leading up to the mouth of the Race might be rendered so tortuous by sunken obstructions as to effectually estop any such procedure. But, this aside, would a ship venture into such a *cul de sac* as Long Island Sound with the "choke" at Throgg's Neck and the Race held by the enemy?

It would seem, therefore, that the interior position at the Race might very well be left to the artillery, while the navy would have the more important exterior lines to look after from Montauk Point to Block Island, from Block Island to Nantucket Island, and from Nantucket Island to Cape Malabar.

Very respectfully,

E. M. WEAVER, 1*st Lieut.* 2*d Art'y.*

Lieutenant Weaver refers to page 181 of his paper as published to show that he did not advocate 20-inch guns for the defense of the Race. On page 180 of his paper, Vol. IX, No. 134, *Journal of the Military Service Institution*, he says: "Therefore for the purpose of this discussion a 20-inch gun is assumed as the standard gun for the defense of our outside line."

There are seventeen feet of water over Valiant Rock; it may be a possible but is hardly a typical site for a turret fort.

The following quotation from Abbot's "Defence of the Sea Coast of the United States" shows why floating defenses are considered necessary for the Race: "One question formerly stoutly contested has been practically answered so many times in late years that there is no longer any difference of opinion upon the subject; every one now admits that a fleet can force a passage past a line of batteries of equal or even of superior armament, provided the channel be unobstructed." R. W.

OPEN LETTER

ADDRESSED TO THE AMERICAN DELEGATES OF THE INTERNATIONAL MARITIME CONGRESS BY THE PROVIDENCE AND STONINGTON STEAMSHIP COMPANY.

Prepared by Lieut.-Commander E. H. C. Leutzé, U. S. N.

Based on the Experience of the President, Captains, and Pilots of the Company.

TO THE AMERICAN DELEGATES OF THE INTERNATIONAL MARITIME CONFERENCE.

Gentlemen:—It is expected that the International Maritime Conference will adopt new rules for the prevention of collisions at sea, new regulations for lights of vessels, fog signals, etc. In the event that these international rules are suitable for our purposes, we intend to petition Congress to make the rules and regulations that govern United States vessels in United States waters the same as the international ones, as simplicity and uniformity in such rules seem to be of the utmost importance. For this reason we beg to submit to you our views on these subjects. They are based largely on personal experience and on the experience of the captains of our steamers, and we hope that they may receive due weight in your deliberations.

General Division 1.

1. Visibility, number, and position of lights to be carried by vessels.

(*a*) Steamers under way.—We consider the lights carried by the Sound steamers as required by Rule 7 of United States excellent in every respect. The "central range" of white lights we consider of the utmost importance, for when end on, or nearly end on, the course of an approaching vessel can be seen to within one point of the compass, and the slightest change of course is immediately detected, and all this without reference to the side lights. When vessels are crossing at right angles, or nearly so, the course cannot be told so closely, but it is then not of the same importance. For that reason the actual position of the lights need not be accurately known, as long as we are sure that the lights are not less than a certain horizontal distance apart, and that the after light is not less than a certain number of feet above the forward one. Should it become a question between the central range and side lights or double side lights, we would strongly favor the former.

If it should be decided that neither of the central range lights be visible all around, as is likely to be the case, on account of masts, smoke-stacks, etc., we would then recommend a white taffrail light in addition, the same to show over an arc of 180° from right abeam around the stern to right abeam.

We do not favor the adoption of distinctive lights for steamers of different speeds, as there seems to be no necessity for them.

We would here call attention to the fact that the captains of our vessels have had actual and constant experience with the "central range" for a number of years, and are therefore excellent judges of their value. They are unanimous and strong in their opinion that they are the best guide for judging a vessel's course or change of course.

We would also invite the Conference to investigate the matter of search lights for steamers. We are of the opinion that, when shaded with a red screen and thrown vertically, they may often be useful in determining a vessel's position in a fog. We base our opinion on this fact, viz.: This company furnishes the lighthouse keeper at Beavertail with red fire, which he burns during foggy nights about the times when our steamers are expected. The loom of this red fire is seen before the lighthouse, or when the lighthouse cannot be seen at all; it is also seen before the fog signal is heard.

(*b*) Steamers towing.—We think that they should be distinguished from other steamers by having the after range consist of two lights carried one above the other.

We also think that all vessels being towed should carry two white lights, one above the other near the stern, a certain number of feet above the deck, and visible all around the horizon.

It is very difficult at present to distinguish the rear vessel of a long tow (such as formed by coal barges, which tow with very long lines), and there are cases on record where vessels have run foul of the long tow lines, as the vessel astern could not be distinguished as belonging to the tow.

(*c*) Vessels under way but not under command.—For this purpose we consider the steam whistle sufficient. A sailing vessel could use her instrument for making fog signals for the same purpose, or the rapid ringing of the bell might be adopted. We have no views in regard to cable steamers, as we do not meet them.

(*d*) Sailing vessels under way.—There seems to be no reason why a sailing vessel should not carry a central range of white lights like a steamer. One of the range lights of either steamer or sailing vessel could have a distinctive feature by which one could be told from the other. Should, however, the "right of way" of sailing vessels be taken away, then there seems to be no absolute necessity for this distinctive feature.

Should the "central range" be considered objectionable, we would then strongly urge that a sailing vessel carry either a bright white light visible all around, or else a white mast-head light visible over 20 points, from right ahead to two points abaft beam on both sides, and a white taffrail light visible over 16 points from right abeam, round by the stern, to right abeam on the other side. The correct principle to start with seems to us, the smaller the vessel, the brighter the light.

It may be urged that the single white light might be mistaken for that of a vessel at anchor, but this does not seem to be any real objection, as objects to be avoided are marked in both cases.

(*e*) Sailing vessels towing.—Should two white lights be the distinctive mark of a steamer towing, we then think that a sailing vessel doing the same work should carry the same distinctive mark, in addition to her regular lights, if she carry no white light; or in place of the one white light, if that is adopted; or in place of the upper range light, in case that is adopted.

(*f*) Vessels at anchor.—They should carry a bright white light visible all around the horizon.

(*g*) Pilot vessels.—They should carry their regular lights (steamer or sailing vessel), and should in addition burn a flare up or flash lights at regular intervals.

(*h*) Fishing vessels.—As these vessels are practically at anchor, we think they should carry the lights of vessels at anchor.

We would add that the lights should be of a certain minimum power, all colored shades should be of a certain standard shade, and all lights should be subject to inspection at any moment, and a fine should be imposed if they are found dirty or wanting in any respect.

2. Sound signals; their character, number, range, and position of signals.

(*a*) For use in fog, mist, falling snow, and thick weather as position signals.

For steamers under way.—It seems to be the consensus of the opinions of our captains, that for steamers pursuing a course, one long blast of the whistle, say of 8 seconds' duration, at intervals of 30 seconds, is the simplest and best signal that can be devised. In this connection we would recommend that some automatic machine for blowing the whistle, with blast of equal length and at regular intervals (Crosby machine, for instance), which can be instantly used by hand, would be an excellent appliance to each steamer, as at present the whistles are blown very irregularly.

We would recommend a very deep or chime whistle as one to be heard best, and would have only one for all purposes. (We must state that we have had no experience with the steam siren that is now fitted to many ocean-going steamers.) The range of the whistle should be about 10 miles in acoustically clear weather; we make this qualified statement as it is a well-known fact that, under certain conditions of the atmosphere, any fog signal, no matter what its range is, is unreliable as to distance and as to direction, and this unreliability decreases as the sound instrument increases in force.

The instrument for making the signal should be situated so that the emitted sound waves shall be as little obstructed as possible by surrounding objects, such as smoke-stacks, masts, or boats. It should be situated as high as possible, and, if practicable, it should be revolving, so as to emit sounds in all directions.

We favor one whistle only, as being less liable to confusion. If there are two whistles, they might be mistaken for separate vessels. Besides, no whistle has the same sound at all times, the difference in tone being caused by different pressure of steam or amount of water in pipes after having been unused for some time.

It is also the consensus of the opinions of our captains, that it is not necessary to have separate signals for vessels standing in opposite directions in narrow channels.

They think it might be well for sea-going vessels to have a code by which one of 8 points (cardinal and quadrantal points) can be signalled, and that, if such code is devised, the vessel signalling such a point should be obliged to steer that course. In no case should any signal be introduced into this course, which may be adopted as helm signal or any other purpose.

For steamers towing.—Steamers towing should have a distinctive signal. We would recommend one long and two short blasts of the whistle. This signal should not signify anything else. We would also recommend that the rear vessel of each tow should make the same distinctive signal with her horn as the towing steamer makes with her whistle.

For sailing vessels under way.—We are of the opinion that a sailing vessel should be obliged to carry a powerful horn, which is to be blown by mechanical means. The least amount of power should be fixed by law, and all horns should be inspected and stamped by the inspectors.

We are also of the opinion that the present fog signal indicating the tack a sailing vessel is on, is of no value. During light winds it is almost impossible, on board of a fast steamer, to judge the direction of the wind correctly. The rule also requires too much thought for a matter which has generally to be decided at a moment's notice.

We think that they should make the same signals with the horn that a steamer would make with her whistle.

Sailing vessels towing.—They also should make the same signal with the horn that the steamer makes with her whistle.

We would here state that we are aware that a more complete code of signals could be devised which would often be convenient, but it would be at the cost of simplicity, and that, as before stated, we consider of the greatest importance.

For vessels at anchor.—The present rapid ringing of the bell seems to be a good signal; the minimum size and tone of the bells should, however, be established by law.

If it should be desirable, we see no objection to substituting a powerful gong for the bell.

Vessels under way, but not under command, including steamers laying cables.—As they are on a par with a vessel at anchor, the same signal would seem to suffice. A steamer could indicate this condition by a continuous blast of the whistle.

(*b*) For use in all weathers as helm signals only.

For steamers meeting and crossing.—We consider the present pilot rules for United States waters good. One short, decisive, blast of the whistle should mean, "I am directing my course to starboard," and two short, decisive blasts, "I am directing my course to port." It is of great importance that these signals should not be used for any other purpose, and should not be included in any code of signals devised to denote a vessel's course during thick weather.

Vessels before turning a sharp curve in a channel where an approaching vessel might be hidden from view should sound a long blast of the whistle at least half a mile before reaching such a curve.

For steamer overtaking.—We do not consider the present arrangement in the United States rules good. In this case, the steamer being overtaken has to answer the same signal which she hears, and would then not be able to steer as she indicates by whistle. For instance, if the overtaking steamer gives one blast of the whistle, she means, "I am directing my course to starboard"; the vessel being overtaken now answers one whistle, which in this case would mean, "I understand; I will let you pass, and, if necessary, direct my course to port." We would suggest that some signal be adopted for these cases, which would mean "I understand," and which should be immediately followed by the whistle, indicating which way the helm is put or which way the ship's head is altered.

For steamers backing.—Three short, decisive, blasts of the whistle should signify, "I am stopped," and should include, "I am backing."

It seems to us that this signal deserves careful consideration; it should be specially stated if "I have stopped" or "I am backing" should refer to the vessel or to the engine.

(*c*) Whether the helm signals shall be made compulsory or remain optional.

We are strongly of the opinion that they should be compulsory in all conditions of the atmosphere, *i. e.*, whether vessels are in sight of each other or not.

3. Steering Rules:

(*a*) Sailing vessels meeting, crossing, overtaken or being overtaken by each other.

(*b*) Steamers meeting, crossing, overtaken or being overtaken by each other.

We consider that the present rules for steamers are excellent and simple, and would recommend them to remain as they are, but their wording should be freed from all ambiguity. Those for sailing vessels are complicated, and though we have little or nothing to do with the management of sailing vessels, we see no reason why the present steamer rules should not be adopted for their use. It would be a great advantage to have the same rules for both, so that officers or pilots who might go from one class of vessels to the other would have no confusion in their minds.

(*c*) Sailing vessels meeting, crossing, overtaking or being overtaken by steamers.

(*d*) Steamers meeting, crossing, overtaking or being overtaken by sailing vessels.

It is a mooted question whether sailing vessels shall continue to have the right of way, or only at certain times, or not at all. It is certainly as easy for them to give way as it is for a long tow, and also as easy for a schooner, for instance, to manœuvre as for a large steamer. In a narrow channel a long steamer can often not steer, when a sailing vessel could tack easily. We would invite the serious consideration on this most important matter by the Conference, and, on the whole, would throw our influence in the direction of *not* giving the sailing vessel the right of way, and specially not in narrow channels.

In this connection we would also invite the attention of the Conference to steamers towing ahead of long tows through narrow channels with smooth water, Hell Gate for instance. Such tows are not manageable, and our steamers have to give way at imminent risk to themselves. We would recommend that in such waters vessels be obliged to tow alongside.

(*e*) Special rules for channels and tide-ways where no local rules exist.—It would be best to frame the rules so that special rules should not be necessary, unless it is also necessary to take a local pilot.

(*f*) Conflict of international and local rules.—The international rules and local rules should be the same.

(*g*) Uniform system of commands to the helm.—Uniform commands to the helm should be adopted, by all means. The first step towards accomplishing this would be to have the steering wheels of all vessels constructed so as to turn in the same way to produce same change in direction of course. The wheels of our steamers turn in the opposite direction from those of sea-going vessels. Helmsmen going from one class of vessel to another, though taught the difference, are apt to become confused at critical moments.

We would venture to suggest that, at the present day, there seems to be no reason why the word of command should not be the same, as both the ship's head and wheel are to go. For instance, the word "Starboard" should mean put the wheel over to starboard, to make the ship's head go to starboard. This seems to be the most logical, and there seems to be only one great objection, and that is, that the present generation of seamen will have to unlearn the habit of a lifetime. And this objection always exists to any change from old to new.

We would also call your attention to the difference in the compass card of different nations. For instance, the French and English compass are different;

for instance, NE¼E in English has a very different meaning from NE¼E in French, the latter meaning NE by E in English. This we think should be changed.

(*h*) Speed of vessels in thick weather.—We think that "fast" speed is the best in thick weather in open water, provided that vessels will stop or slow immediately on hearing another vessel's fog signal, and will remain so until danger of collision is past.

We give the following reasons: The vessel is less liable to be drifted by currents and tides, therefore more sure of her position, and less apt to drift into the course of a vessel coming from an opposite direction, where vessels follow regular lanes. She will get through a fog bank more quickly, and thus lessen time in which she is liable to collision. She will be under better command of helm. The minimum speed at which large steamers are under control is so great that the effect of collisions is nearly as disastrous as at full speed. When going at a slow speed, a good head of steam must be kept to give an effective back-turn of the engine, and this frequently causes the blowing off of steam, which (unless vessels are fitted with mufflers) will prevent other vessels' signals from being heard.

The fast speed is also most in accordance with the wishes of the public. A steamship line that would habitually deliver passengers, mails, and freight later than any competing line, from no matter what cause, would probably lose the greater part of its business.

In narrow channels we would recommend that vessels should go slow or anchor.

GENERAL DIVISION 2.

(*c*) Discipline of crew.—We would here suggest that it be made obligatory for all vessels to carry a bow lookout.

GENERAL DIVISION 6.

(*a*) Uniform system of examination for the different grades.—We are of the opinion that it would be a safeguard against loss of life, etc., if the captains, pilots, and engineers of pleasure boats, yachts, steam, and naphtha launches were required to have certificates of efficiency.

GENERAL DIVISION 11.

Under this general division we would call the attention of the Conference to the present indiscriminate use of electric lights on wharves, bridges, in cities and parks. We would strongly urge that some measures be taken that any such lights which may interfere with the navigation of adjacent waters be shaded towards such waters.

At present they blind the pilots, interfere with range lights, and mislead greatly in judging distances.

The electric lights on the Brooklyn bridge are a constant source of danger to our steamers. Underneath the bridge it looks like a black wall to the pilots, who are blinded from the glare above, and they cannot distinguish anything. In fact, these lights have about the same effect that the high electric lights at Hell Gate had. That these were a failure was conceded by the U. S. Lighthouse Board, which had these lights and tower removed.

In conclusion we would state that in framing the new rules all ambiguity in wording them should be carefully avoided. We would also again call attention that simplicity in all rules is of the utmost necessity. They have to be applied at a moment's notice by men of different grades of intelligence, and they should be able to do so without consulting printed regulations or without having to search in their minds for a proper solution. With this view we have refrained from recommending more elaborate systems of lights, fog signals, or code of course and steering signals.

Respectfully,

(Signed) J. W. MILLER, *President P. & S. S. Co.*

THE BOMBARDMENT OF UNFORTIFIED, UNRESISTING CITIES.

[Reprinted from the *United Services Gazette.*]

The capture of the Scotch and the bombardment of the English ports, described in our issue of the 31st ult., has again opened up the question whether, in time of war, an unfortified, unresisting city may be bombarded. As the views expressed on this point which have already appeared have been rather contradictory, we refer our readers to an essay by Captain W. T. Sampson, U. S. N., on this topic. He says:

"Those writers on international law who mention the subject lay it down as an acknowledged rule that an unresisting city may not be bombarded. In this matter it is certain that a broad distinction exists, which has not been recognized by writers upon this subject, between the bombardment by an army and a bombardment by a naval force. In the case of an advancing army, it appears most reasonable that it should not bombard a city which offers no resistance, for the army has only to take possession. To bombard under such circumstances would be not only useless, but inhuman: all right-minded people justly condemn it.

"The case is quite different, however, when it is a question of the bombardment of an unresisting city by a naval force; it being understood that resistance would be offered if the naval force should land to take possession. The naval force has the power, as had the army, to inflict injury upon the city, and compel compliance with its demands, but in a different way; and this difference in the form of the force involves a modification of the international rule when applied to bombardment by a naval force."

Upon this point Calvo, a French authority on the law of nations, says: "In no case, under no pretext, is it permitted to bombard an open unfortified city which is not defended by military. To act against such places as the necessities of war authorize to be done against fortresses is to violate all the laws of nations, and to place one's self outside the law of those nations which march at the head of civilization."

"Among the modern cases of this kind which have most awakened public attention may be cited the bombardment of Valparaiso in 1866 by the Spanish squadron, under the command of Admiral Mendez Nunez, which constitutes a deplorable precedent of the application of force as a means of resolving an international question."

"Further upon this subject the same author cites several cases where the attack upon fortified cities was directed upon the fortifications and other defenses, and not upon the city itself, and commends this mode of proceeding as causing less bloodshed. This is, however, questionable and in strong contrast to the business methods inaugurated by Farragut, who passed the fortifications and brought the cities directly under the guns of his fleet. In these cases it cannot be said that the bloodshed was increased."

"The manœuvres of the British fleet during the summer of 1888 led to a very animated discussion, both in the press and in Parliament, upon the question of bombarding undefended cities. All naval and military authorities agreed that it was a kind of warfare likely to ensue in case of hostilities, and that it should be prepared for; while others declared that the rules of civilized warfare forbade such bombardment, and some even went so far as to declare such cities as Greenock would require no defenses, that they would not be molested by any probable enemy. Unfortunately, it cannot be assumed that such opinions were not, to some extent at least, biased by political views. Those in England who think that the navy should be increased took one view, while those opposed to any material increase in the naval force, whether from economical reasons or from opposition to the Government, were led to adopt the view that would require the least preparations for defense."

"One English authority on international law quotes the rules laid down by the military delegates of all European states to the Brussels Conference in 1874, and says that, with the necessary changes in wording, these rules apply to the operations of naval forces against places on land."

The rules that interest us at this time are as follows:

"Art. 15.—Fortified places are alone liable to be besieged. Towns, agglomerations of houses, or villages, which are open or undefended, cannot be attacked or bombarded."

"Art. 16.—But if a town, etc., be defended, the commander of the attacking forces should, before commencing a bombardment, and except in the case of a surprise, do all in his power to warn the authorities."

"As before explained, the rule laid down in Art. 15 is for land forces, and requires material modification before it can be made applicable to a naval force. It is more than likely that the commanding officers will receive specific instructions covering all doubtful cases. The Spanish admiral was so instructed in the case of Valparaiso."

"A city may be defended by armed men only, and consequently be totally unprepared to resist a naval attack; or it may even be fortified to prevent the approach and landing of a naval force, and yet be exposed to destruction by bombardment. No restriction can be placed upon a naval force in either case to prevent bombardment. If such a city refuses to comply with any reasonable—even though exorbitant—demands made upon it, it lays itself liable to bombardment by an enemy having the power to inflict such punishment. On the other hand, it may be safely stated, as a rule, that a naval force intending to bombard a city must give ample warning of its intention, and, if anticipating the approach of succor, must abandon its intention rather than attack without such warning as will permit the escape of women and children. Even should the object of the bombardment be to destroy military or naval depots, it cannot be done without warning, if the lives of non-combatants would be endangered thereby. A notification of intention to bombard should be given only when the naval force is present. It should not be considered proper warning should an enemy telegraph along the coast or to any particular city that it would be bombarded on a specified date."

"Many rules of international law are deliberately violated when it appears to advance the interests of the violator, and there is the necessary power to brave the consequences. It is for this reason that the protection offered by many of the wise and humane rules of international usage are not to be relied upon.

"But this rule, that a city shall not be bombarded without due notice which will permit women and children to be removed beyond possible injury, is a rule no civilized nation would venture to disregard."

"During the manœuvres of the British squadron in 1888, the Irish squadron eluded the blockade of their English enemies, and engaged in a raid upon the English coast, bombarding Greenock, Liverpool, and other unprotected cities. Greenock harbor was entered by a single vessel one Sunday morning and bombarded immediately, without any communication with the shore, and while the people were at divine service. This does not represent actual warfare, because no commander would bombard an open city without first making a demand for a ransom or the fulfilment of any conditions he might see fit to impose. No impossible demand should be made, with the alternative of bombardment in case of refusal. Reasonable time must be granted for a reply, and, in case of refusal, further delay must be granted to permit non-combatants to leave the city. A large sum of money, for example, cannot be produced at a moment's notice, and such transactions must be conducted upon a strictly cash basis. The citizens would doubtless request a modification of the demands, all of which negotiations would require time. This could not be refused by the commander, except in cases of extreme necessity involving the safety of his ship, and even then he would have to face the execrations of the whole world for his inhumanity. In any case, more time would be consumed than ten hours, which was permitted by the English rules."

"We shall see that this has a very important bearing upon the naval defense of a city. The time element that the rule involves furnishes a great advantage to the defenders. The modern practice regarding bombardment of unfortified cities, as in the case of Valparaiso, is directly opposed to the international rule against it. At the same time, the popular conviction of what would take place in event of a foreign war is in harmony with the views expressed above."

"If further argument was necessary to show that an unfortified city may be bombarded by a naval force, it may be found in the statement that if bombardment is not permitted under such circumstances, then complete protection is to be had by non-resistance. An unfortified city that offers no resistance to a naval force would be exempt from molestation, because the naval force, when landed, would be too insignificant to contend with the land force that would then be developed to oppose it. When a fleet has made a demand for a ransom upon a fortified city and the ransom has been refused, the fleet cannot be expected to abandon its position of advantage, its power as a fleet, and land its men and attempt to take by a landing party what was refused to the fleet. If such a construction could be put upon the general rule that unfortified cities may not be bombarded, then it would become absurd, and in coast defense naval supremacy would have no significance."

In examining the different accounts of the raids carried out by the ships of A and B fleets during the late naval manœuvres, we cannot fail to see that, judged by the opinions given above, the performance of the raiding vessels, as regards the time taken, was different from what would be expected in actual warfare.

But enough was done to show that—

1. Unfortified, unresisting cities must expect to be bombarded unless they cash up pretty sharp.
2. The telegraph system failed to give warning in time for the defending force to send succor.
3. Floating defenses, unless very powerful, are of no account.
4. Our military defenses at such places as Aberdeen and other coast towns require strengthening considerably. It is very evident, if we had to fight active and energetic enemies, that, long before their fleet could be destroyed, these military defenses would be brought into play.
5. The torpedo-boats have to score another failure in their powers of offense.

The advantage in speed and size our powerful new battle-ships will have if acting against slightly fortified towns was illustrated by the feats accomplished by the Anson, who distanced all pursuers and always turned up where least expected.

TORPEDO-BOATS FOR THE BRITISH GOVERNMENT.

[Reprinted from the *United Services Gazette.*]

An interesting and very successful trial was on Saturday last made of two of the second-class and one of the first-class torpedo-boats now being built by Messrs. Yarrow & Co., of Poplar. We were much struck by the general handiness, and observed many marked improvements on all previous types.

The firm have on the point of completion ten of the second-class boats for the Admiralty. These are modifications of "No. 50," which was constructed two years ago, and which was also the result of competitive designs submitted to the Admiralty authorities. They are 60 feet in length by 9 feet 3 inches beam, which secures them very fine seagoing qualities. These boats have a guaranteed speed of 16 knots during a run of two hours, carrying four tons. They may be considered as the standard type of second-class boat to be adopted in future in the British Navy. They are to serve as tenders to our large ironclads, and not only to be used as torpedo-boats, but also for the general service of the ships to which they are attached. The lifting weight averages about twelve tons. They are entirely decked from end to end, which is essential to ensure thorough seagoing qualities; the machinery, of the triple expansion type, is capable of indicating about 200 horse-power. There are small cabins both forward and aft, but in a boat of this size much accommodation cannot be expected. As previously stated, this order was given to Messrs. Yarrow & Co. in consideration of the success of "No. 50," built by them, which has been considered, from actual service, to be a great improvement on the old-fashioned long and narrow second-class torpedo-boats which were previously adopted in the service. As a matter of fact, the present boats, with their far greater beam, actually have a speed of fully half a knot more than those that were formerly constructed, and which were really not safe at sea in rough weather. These second-class boats are built throughout of steel, which is the only material at all suitable for craft of this description, as a wooden structure, if decked in completely, which is essential to make it thoroughly seaworthy, would deteriorate rapidly in consequence of the heat radiated from the boiler.

Last year proposals were invited by the Admiralty authorities for six first-class torpedo-boats, which it was intended to add to the navy during the present year. The designs submitted by Messrs. Yarrow & Co. were those to which preference was given, partly in consequence of their guaranteeing a higher speed than any other firm. These boats are, as regards all leading particulars, similar to "No. 79," a sample boat, constructed three years since by the above firm, and which gave specially good results, on account of her excellent speed, combined with exceptional manœuvring powers. The official trial of "No. 79" was fully reported in the press at the time it took place. As is well known, she has become the favorite torpedo-boat in Her Majesty's Navy, and it will be remembered by our readers that this one was selected to be placed under the command of Prince George of Wales during the naval review and recent manœuvres.

The new boats, which embody all the latest improvements, are 130 feet in length by 13 feet 6 inches beam. They are constructed of galvanized steel, and propelled by triple expansion engines indicating about 1150 horse-power. All six boats have now been tested officially by the Admiralty authorities, the trial speed consisting of a run of three hours' duration, without stoppage of any kind, carrying a load of 20 tons; and the speeds attained have varied from 22½ to 23 knots, the actual speeds being 22.53, 22.57, 22.64, 22.62, 22.59, 23.03, from which it will be seen how remarkably alike the results in all the boats have proved to be.

In comparing these boats with those constructed during the last Russian scare, four years since, it will be of interest to note that the former ones were stipulated, by the authorities then in power, to have a speed of nineteen knots during two hours, carrying a load of ten tons, whilst the present boats actually give from three and one-half to four knots more during a run of three hours, with ten tons greater load. These results represent the rapid advance which has been made in torpedo-boat construction in this country during the last three years. The trials of these boats show that an equal advance has been made as regards steering efficiency and rapidity of manœuvring, which is of almost equal importance to speed.

The forward part of the boat, extending from the bow to the conning tower, is devoted to the accommodation of the crew, and immediately aft of this compartment is a small space containing galley, electric-light plant, and stores. Aft of this is placed the boiler, which is of the locomotive type, but of exceptional size and power, so as to avoid any straining, which recent experience, both in the British and foreign navies, has shown to be so detrimental to the durability and reliability of the boiler, to enable steam to be maintained by comparatively untrained men. We believe that a locomotive boiler, if properly designed and constructed of the best materials and workmanship, should be a thoroughly reliable, and probably the most advantageous steam generator, and in all those torpedo-boats constructed by Messrs. Yarrow & Co.; there has never, as far as we are aware, occurred any accident, although hundreds of these vessels are now afloat and in constant service. The great secret of construction to make a boiler reliable seems to be to design it so that the various parts can accommodate themselves, without strain, to meet the changes of form due to expansion and contraction, owing to variations in the rate of combustion and of pressure. If this main principle is kept always in view in the design, we are fully confident that there should be none of the troubles frequently experienced in working boilers under forced draft, which is mainly due to the rigidity of their construction; and under those circumstances, when any part requires to change its form, however small, owing to the expansion and contraction due to changes of temperature, an overwhelming force is involved, and something must in consequence give way. Another special feature in these new boats, and one of great importance to fighting ships, is the adoption of Yarrow's system of enclosing the furnace, or fire-box, of the boiler in a complete water-tight casing. In this system all the air which is required for the purpose of combustion has to pass over the casing and then downward to the furnace. The effect of this is to prevent the extinction of the fire, should a sudden inrush of water find its way into the stokehole or boiler compartment. The importance of securing immunity from this will be self-evident when the probability of damage to the thin steel plates of the hull through shot or collision is borne in mind. It has been found that when the boiler compartment is filled with water the steaming power of the boat is sufficiently maintained to enable it to run fully fifty miles without a fireman entering the stokehole. Aft of the boiler compartment is the engine room, in which are placed triple expansion engines capable of indicating about 1150 horse-power. Within the engine room, in addition to the propelling machinery, there are two engines for compressing air for the use of the torpedoes; an engine for driving the ventilator, which forces the air under pressure to the furnaces; also an engine for producing a current of water through the surface condenser, and an engine for steering the boat. Further aft we come to a cabin compartment, in which is supplied sleeping accommodations for two engineers; also the magazine for the supply of ammunition for the machine guns. Aft of this we come to a neatly fitted up cabin for the officers, and further aft a pantry for the officers' use. The armament consists of one torpedo-gun for direct ahead fire, placed forward below the turtle deck and secured into the stem of the boat. Near the stern is provided a turntable, on which are placed two torpedo-guns for side fire. These two guns are placed at an angle of five degrees with one another, arranged on Yarrow's patent system; by which means, if the two torpedoes are fired simultaneously, by taking slightly divergent courses, they cover a much larger area, and consequently ensure much more certainty of hitting the vessel aimed at, on the same principle that in firing at a bird on the wing a number of small shots are adopted, which disperse, in preference to firing one shot only. This system of arranging the torpedo-guns is now becoming largely adopted, especially for side fire, where the difficulty of accurate aim is enhanced. The machine-gun armament consists of three 3-pounder quick-firing guns, one amidships and one on each beam, in echelon. Steering gear is fitted at two points, one within the conning tower (which would mainly be used in time of war) and aft, in front of which a movable brass shield is placed for the protection of the steersman.

As regards the manœuvring power of these boats, it may be mentioned that they can turn to port or starboard within a circle the radius of which is only a trifle in excess of the length of the boat, and this result is obtained by means of only one rudder of the simplest construction. The times occupied in turning circles when running at full speed averaged seventy-five seconds. The rudder is designed in such a manner that when hard over it counteracts the natural heel of the boat, thus maintaining a steady platform, and avoiding at the same time the risk of capsizing, to which torpedo-boats, both in the French and Danish navies, have lately shown themselves liable. The trials of these boats took place below Gravesend, and the above speeds were obtained during runs over the measured mile at Lower Hope, at intervals determined by the Admiralty authorities during the run of three hours, and therefore represent the mean speed of the three hours' run. There is one point in the construction of these boats which should be noted, viz., the bulkheads are throughout intact, there being no opening or door of any kind in them, and which experience has shown to be so often open at the very time when the subdivision of the hull is most needed.

In addition to sixteeen boats which Messrs. Yarrow & Co. are now on the point of completing for the British Government, they have also in hand fourteen for foreign governments.

CAST-IRON MORTAR.

[Reprinted from the *Army and Navy Register*.]

The 12-inch cast-iron mortar, which was submitted to the Ordnance Department by Wm. P. Hunt, Esq., of Boston, for testing under the terms of the act of Congress of last winter, has gone to pieces at Sandy Hook, and it is possible that we may hear no more of cast iron as a material for heavy ordnance in this country. The mortar broke up on the twentieth round with a charge of only 55 pounds of powder. It had been fired round for round, under the same conditions as the steel-hooped mortar, which has been fired over 200 times, and the record of the pressure gauges on the exploding charge were not excessive, being less than 30,000. The mortar burst on the 3d inst., Mr. Hunt being present at the time.

BOOK NOTICES.

THE WAR DEPARTMENT AT THE CENTENNIAL EXPOSITION, CINCINNATI, OHIO, 1888.

This is a complete catalogue of the War Department exhibits, arranged by Capt. A. H. Russell, U. S. A. The exhibits are so arranged as to present a historical series, outlining the development of firearms from the earliest period. Besides ordnance stores, there were articles from Quartermaster and Signal Departments. The clear and concise description of each article adds greatly to the value of the catalogue.

THE DEVELOPMENT OF GREAT CIRCLE SAILING. By G. W. Littlehales, U. S. Hydrographic Office.

The preface to this work, signed by the Hydrographer, shows its value: "This publication has for its object the furtherance of the effort of the Bureau of Navigation of the Navy Department to keep pace with the progress of the nautical sciences. It consists of an exposition of graphical and analytical methods embodying cardinal principles relating to the great circle, as applied to navigation, and gives publicity for the first time to several of the most convenient and useful methods yet devised.

"The actual state of the science of great circle sailing is here presented so as to give a clear conception of each method, and to furnish references where more extended information can be found.

"(Signed) GEORGE L. DYER."

CATALOGUE OF STARS OBSERVED AT THE UNITED STATES NAVAL OBSERVATORY, 1845–77. By Prof. M. Yarnall, U. S. N. Third edition revised by Professor Edgar Frisby, U. S. N.

The corrected edition of the Star Catalogue will be of value and interest to such naval officers as are acquainted with the use of the zenith telescope, as it is a useful addition to the B. A. Catalogue. The original edition was mainly composed of stars used in the army surveys for observations for latitude with the zenith telescope. R. W.

BIBLIOGRAPHIC NOTES.

AMERICAN CHEMICAL JOURNAL.

VOLUME XI, NO. 4, APRIL, 1889. Morse and White show that oxides of zinc or cadmium are dissociated in zinc or cadmium vapor respectively. Smith and Frankel give method for the electrolytic separation of mercury from copper. Drown and Martin apply the Kjeldahl method to determine nitrogen in waters. E. H. Keiser reviews recent syntheses in the sugar series.

NO. 5, MAY. Ira Remsen discusses the structure of "double haloid salts." Morse and White show that the sulphides of zinc and cadmium are dissociated in the vapors of their respective metals. Smith and Frankel give method for electrolytic separation of cadmium from zinc. Notes: Allotropic forms of silver, by Carey Lea; Determination of iron in presence of hydrochloric acid by means of permanganate of potassium, by C. Reinhardt.

NO. 6, SEPTEMBER. E. H. Keiser redetermines the atomic weight of palladium, finding the figures 106.35. C. R. S.

ANNALEN D. HYDROGRAPHIE U. MARITIMEN METEOROLOGIE.

17TH ANNUAL SERIES, NO. 6. Report of experiments made at the German Observatory to establish the conduct of marine chronometers when placed on movable foundations. Report on Santos, by Capt. Fr. Niejahr, Commander of the German bark J. F. Pust. Extracts from the log of Captain Reesing, of the German steamer Thuringia. Sailing directions for the Congo from its mouth to Boma. Description of the east coast of Sipora or Sikabou, west coast of Sumatra. The sudden fall of the barometer in Middle Europe.

JAN. 31–FEB. 1, 1889. Quarterly weather review of the German Observatory for summer of 1885. Minor notices: Sandwich Harbor (Port D'Ilheo), west coast of Africa; Remarks on Walfish Bay; Voyage from Walfish Bay to Cape Town; Weather and currents near Barbadoes.

NO. 7. General index of the Annual Series from 1873 to 1888.

NO. 8. Tides on the coasts of the Netherlands. Normanton, Gulf of Carpentaria, Australia—report of Captain F. Rumpf, of the German bark Balcarry. Reports on voyages in the East India Archipelago, by Capt. L. A. Meyer, of the ship Kriemhild. Steamer routes between Aden and the Netherland East India possessions. Report of the twelfth competitive examination of marine chronometers, held at the German Observatory during the winter 1888–1889. Quarterly weather review of the German Observatory, summer 1885 (conclusion). Minor notices: Extraordinary heavenly phenomena; New ship channel to Melbourne; Harbor of Fremantle, west coast of Australia; Humboldt Bay; Bottle post; Observations of earthquakes at the Imperial Observatory at Wilhelmshaven.

E. H. C. L.

BOLETIM DO CLUB NAVAL.

February to June, 1889. Reorganization of the fleet. Theory of the rudder. Study on the construction of boats peculiar to Brazil. Repeating rifles. Notices to mariners. The naval school. General considerations on steam engines. Study on naval hygiene.

J. B. B.

BOLETIN DEL CENTRO NAVAL.

March, 1889. The Nicaragua Canal. Naval wars in the future.

April. Naval wars in the future. A. C. B.

BULLETIN OF THE AMERICAN GEOGRAPHICAL SOCIETY.

Volume XXI, No. 3, September 30, 1889. A look at Algeria and Tunis. The Portuguese in the track of Columbus. Geographical notes.

DEUTSCHE HEERES ZEITUNG.

No. 52. Paper torpedoes.

Experiments made in Germany with torpedoes made of paper, loaded with a charge of 25 pounds of dynamite, propelled and fired by electricity. Very satisfactory results are said to have been obtained with these new torpedoes, which possess great solidity and elasticity against shock.

Naval manœuvres at Zoppot (Germany).

Consisting of landing manœuvres with a large force and artillery exercise at night with electric targets.

No. 54. Electricity on submarine boats. Description of the French submarine boat Gymnote: experiments at Toulon. Russia: launching of the ironclad Emperor Nicolas.

No. 55. Krupp's trials of a new powder.

Since the publication of Krupp's last report, No. 73, October, 1888 (mentioned in No. 49, Vol. XV, 2, of the Proceedings), new trials with the prismatic powder manufactured by the United Rheinisch-Westphalian Powder Mills have developed a still further increase of efficiency.

No. 58. The Satean Poisson of Mr. Gonbet (France). Torpedo trials in the U. S.

Nos. 59, 60. The French naval manœuvres. Accidents to torpedo-boats. Russia: organization of torpedo divisions.

Nos. 65, 66. Trials with explosives. Launching of the German coast defense armor-clad vessel Siegfried at Kiel (August 10, 1889). Changes in the foreign stations of German vessels. Contribution to the English "gun question." Russian naval manœuvres.

Nos. 67, 68. The French torpedo-boats. Shipbuilding in England. Numerical strength of the fleets of Europe at present and in 1894.

No. 70. Use of electricity for coast defense in the United States.

Nos. 72–74. The pneumatic dynamite gun and its use for coast defense and at sea (lecture by Captain Zalinski before the Royal United Service Institution). Return and reception at Kiel of the crews of the German vessels wrecked at Samoa. Modification of French torpedo-boats. Report on the trials of torpedo-boats in Spain. H. M.

JOURNAL OF THE AMERICAN SOCIETY OF NAVAL ENGINEERS.

Volume I, No. 3, August, 1889. The manufacture of steel castings. A brief account of the method of working spirally welded tubing. Some lessons from Samoa.

In this paper Chief Engineer McKean mentions among the important lessons to be learned from this disaster, 1st, the necessity for increased power, as, if our ships had power approaching that of the Calliope, some of them at least might have "clawed off"; 2d, protection to propellers; 3d, greater security for the smoke-pipe; 4th, the great advantage of having the bilge pumps and strainers perfectly accessible; 5th, the advisability of having one rocket apparatus, or life-saving gun, capable of being moved to any part of the spar deck, and always ready for use; 6th, with water rising rapidly in the holds, in many cases provisions could not be reached. It would not be impossible to have some concentrated ration in small bulk stowed in lockers fore and aft; and in case of abandoning ship from any cause, this supply could be available for the boats; 7th, exercising the men in diving with the aid of suits or other apparatus. The armor would often be of great service in clearing propellers, closing orifices temporarily for repairs, examining copper, etc., etc.; 8th, the position of the hawse pipe will no doubt receive due attention in our new ships, though in them the water-tight bulkheads should at least prevent the fires from being extinguished.

Phenomena attending ship propulsion.

A discussion on Chief Engineer Isherwood's article on this subject.

Report of the performance of the S. S. Meteor. Acts of Congress applying to new vessels. Space occupied by the machinery of some of the new cruisers. Ships and steam trials. English naval manœuvres. Combined indicator cards of the U. S. S. Yorktown.

J. K. B.

JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES.

July, 1889. Duty trials of pumping engines, by Geo. H. Barrus.

August. Steam plants for electric service, by H. Bryan. A system of marking patterns, by A. J. Firth.

September. High-service system of the Boston water works.

F. H. E.

JOURNAL OF THE U. S. CAVALRY ASSOCIATION.

VOLUME II, No. 5. Cavalry war lessons. The pistol versus the sabre for light artillery. Identification of deserters. Letters on cavalry. Marching and camping cavalry and caring for horses in the field. Drill regulations for cavalry, United States Army.

No. 6. A horse's foot. My ride around Baltimore in 1864. Letters on cavalry. New drill regulations for cavalry, United States.

JOURNAL OF THE FRANKLIN INSTITUTE.

AUGUST, 1889. On Koyl's parabolic semaphore.

SEPTEMBER. Aluminium. Harbor bar improvements.

OCTOBER. Experiments on the efficiency of pumps. Harbor bar improvements. Mechanical progress. The past and present contrasted.

NOVEMBER. The aneroid barometer.

JOURNAL OF THE MILITARY SERVICE INSTITUTION.

VOLUME X, No. 39. An American war college. Mobilization. More about cavalry gaits. New course of instruction, Fort Monroe. The infantry in the field.

No. 40. Puget Sound; a sketch of its defenses. The development and use of hasty intrenchments for infantry. Desertion in the United States Army. Some thoughts with reference to the organization of our artillery. The uniform of the West Point cadet.

No. 41. Personal identity in the recognition of deserters. An interoceanic canal. Use of railroads in war. Military training of the regular army. Revision of our infantry tactics. R. W.

MECHANICS.

MAY, 1889. Notes on steel inspection of structure and boiler material. Wind pressure. The propellers of the Baltimore. An investigation of experiments made on a centrifugal blower. The Riehle adjustable transverse elastic limit indicator.

JUNE. The American Society of Mechanical Engineers.

A special report of the meeting of this society, with an abstract of papers on the comparative cost of steam and water power; notes on the comparative loss by friction in a transmitting dynamometer under different loads and speeds; steam consumption of engines at various speeds; standards; notes on the steam turbine; the tractive force of leather belts; longitudinal riveted joints of boiler shells; the use of petroleum in steam boilers; the piping of steel ingots; some properties of vapors and vapor engines; cylinder ratios of triple expansion engines and the performance of a 35-ton refrigerating machine of the ammonia absorption type.

JULY. The Thorneycroft boiler. The application of photography to surveying. Practical hints for gearing. An improved engine indicator.

SEPTEMBER. Economy in the use of belting. Water gas in steel furnaces. Technical education. Testing cast iron. Corrosion and pitting in marine boilers. J. K. B.

MITTHEILUNGEN AUS DEM GEBIETE DES SEEWESENS.

VOLUME XVII, NOS. 7 AND 8. England and the Declaration of Paris. Launching torpedoes by means of powder in the French navy. Nautical science during the ages of the greatest discoveries. Dangers in the management of engines on board of vessels. Advance in photogrammetrie. Ballistic photographic experiments in Pola and Meppen, by Prof. E. Mach and P. Salcher. Armor of battle-ships, by Sir N. Barnaby. Wreck of the German men-of-war in Apia. Apparatus to ensure a constant and steady platform for guns. New paint for bottoms of iron and steel ships. Henderson's folding life-boat. New method for raising the armor-clad Sultan. Screw-propellers for light-draught vessels. New vessels for the Chilean navy. Greek armor-clad Hydra. Launch of the torpedo cruiser Planet. Arduis' optical-electrical signal apparatus for vessels. Electric engine telegraph. English torpedo supply vessel Vulcan. Legé torpedo. New type of American torpedo-boats. New air-compressing pump for torpedo purposes. Paper torpedoes. Torpedo-boat dock for the French navy. Official programme of the International Maritime Conference at Washington. Remarks on hurricanes. Cleaning of chronometers. The 2000-ton steel cruisers of the United States navy. Competition for plans of a Russian armor-clad. Arming of English vessels. Names of English men-of-war in process of construction. Armor of the Italian men-of-war in process of construction. Branch of the firm Krupp in Italy. Quick passage across the Atlantic. Italian cruiser Piemonte. Model of ocean currents. Literature. Bibliography.

NO. 9. Electric lighting, with special reference to its application on shipboard. Boilers. Movement indicator. Precautions against the effect of electric light on ships' compasses. Coaling at sea. Trial of a Brennan torpedo. Scott's electric log. Trials with propellers in England. Trial trips of English men-of-war. Four-hour full power run of the English Mediterranean squadron. New torpedo scouts for the French navy. Laying the keel of the English protected cruiser Pallas. Construction of three English cruisers of the Medea type. Rapid-firing cannon of the Skoda pattern. New English torpedo-boats. Torpedo-boats for the Argentine Republic. New French men-of-war. Literature. E. H. C. L.

NORSK TIDSSKRIFT FOR SOVAESEN.

SEVENTH ANNUAL SERIES, NO. 6. How can collisions at sea be avoided, etc. Remarks on Capt. O. Hansen prize essay: Necessary strength of army and navy, and armament required for coast defenses of Norway and Sweden, by Col. Giertsen (conclusion).

Future naval wars. New electric boat. Protection and armor of English vessel. Inland navigation of Russia. The Formidable. Capsizing of a French torpedo-boat. John Ericson. Neutralization of the Banks of Newfoundland. Spanish submarine boat.

E. H. C. L.

PROCEEDINGS OF THE INSTITUTION OF CIVIL ENGINEERS, LONDON.

Vol. XCVI. Some canal, river, and other works in France, Belgium, and Germany, by L. F. Vernon-Harcourt. Economy trials in a non-condensing steam engine: simple, compound, and triple, by Peter W. Willans. Selected paper No. 2394: Tests of a Westinghouse engine, by S. Alley. Foreign abstracts: Excavations for the locks on the Panama Canal, by Max de Nansouty (*Le Genie Civil*). Corinth Ship Canal, by Armand Saint Yves (*Annales des Ponts et Chaussées*, Vol. XVI). The basic open-hearth process at Gratz, by F. Moro (*Stahl und Eisen*, 1889). On nitrogen in Bessemer and open-hearth steel, by H. Tholander (*Jernkontorets Annaler*, 1888). Regulators for electrical distribution, by George Marier (*Annales des Mines*, 1888). On the nature of the welding of iron and nickel, by T. Fleitman (*Stahl und Eisen*, 1889).

Vol. XCVII. Alternate current machinery, by G. Kapp. The district distribution of steam in the United States, by C. E. Emery, Ph. D. Selected papers: On steamers for winter navigation and ice-breaking, by R. Runeberg. West of India Portuguese Railway and harbor works, by E. E. Sawyer. On the new steel dock gates of Limerick floating dock, by W. J. Hall, B. E. Perforated cake powder for ordnance, by G. Quick (abstract). The removal of rock under water without explosives, by F. Lobnitz. Foreign abstracts: Automatic maximum and minimum tide register, by C. T. van Sluys (*Tijdschrift van het Koninklijk Instituut van Ingenieurs*, 1888–89). The permeability of Portland cement mortar and its decomposition by sea water, by L. Durand-Cloye and P. Debray (*Annales des Ponts et Chaussées*). Note on a glass apparatus for rendering visible the effects of condensation and evaporation that take place inside a steam engine cylinder, by B. Donkin, Jr. (*Bulletin de la Société Industrielle de Mulhouse*, 1889). The port of Buenos Ayres (*El Ingeniero Civil*, Buenos Ayres, December 15, 1888). On the industrial and economic value of dynamo-electric machines, by R. Arnoux (*L'Electrician*, 1889). Measurements of the resistance of insulators with varying electro-motive force, by F. Uppenborn (*Centralblatt für Electrotechnik*, Vol. II, 1889). F. H. E.

PROCEEDINGS OF THE INSTITUTION OF MECHANICAL ENGINEERS.

January, 1889. On the use of petroleum refuse for fuel. Compound locomotives.

May. Report of the Research Committee upon steam engine trials. The trial of the S. S. Meteor. J. K. B.

THE RAILROAD AND ENGINEERING JOURNAL.

MAY, 1889. The development of the modern high-power rifled cannon. French armored cruisers.

An account of the latest additions to the French navy, which include armored cruisers of three classes, outline sketches and deck plans.

Experimental guns for the army.

JUNE. United States naval progress.

The plans and specifications of the new vessels, together with an account of the rate at which the vessels now under construction are approaching completion.

The development of high-powered rifled guns. The escape of the Calliope. Hydraulic engine for loading guns.

A description of the mechanism for working the guns on board the Edinburgh and Colossus.

The new English battle-ships.

The principles laid down by the English Admiralty for the design and construction of eight new battle-ships of the first class.

Corrugated tubular fire-boxes for locomotives.

JULY. United States naval progress (a description of the design for the new 2000-ton cruiser). Quadruple-expansion engines of the steamship Singapore. Nickel steel.

In a paper read before the British Iron and Steel Institute, the author stated the result of an examination made into this new alloy of nickel and steel. His experience led him to conclude that the alloy can be made in any good open-hearth furnace, working at a fairly good heat. Its working demands no extraordinary care. No special arrangements are required for casting, the ordinary ladles and moulds being sufficient. The new alloy has an advantage over ordinary steel, because it does not easily corrode. Steels rich in nickel are, in fact, non-corrodible, and those poor in nickel are still much better in this respect than ordinary steel. Alloys up to 5 per cent of nickel can be readily worked in the lathe or planer, but richer alloys are more difficult to work. Poor alloys stand punching very well. The one per cent nickel steel welds fairly well, but richer alloys do not weld easily. In the test of this material, one piece tested gave: breaking strain, 95 tons; elastic limit, 54 tons; extension (in 4 ins.), 9.37 per cent; contraction of area, 49 per cent. Other pieces gave nearly parallel results. The author states that gun-barrels made of nickel steel stood very high tests, and that a 6-inch gun of this metal had been ordered by the English Government.

AUGUST. Sketches and description of the English battle-ship Benbow and the Italian cruiser Piemonte. Hydrography and hydrographic surveys.

OCTOBER. Hydrography. Oil as a metallurgical fuel. Illustrated description of electric light installation for United States cruisers. The development of modern high-powered guns (continued). J. K. B.

REVUE DU CERCLE MILITAIRE.

JULY 7, 1889. The defense of the Vosges, and mountain warfare. The Danish army on a war footing. The war exhibit at the Paris Exposition (continued).

JULY 14. The ancient marine at the Palais des Beaux-Arts, with cuts in the text. The defense of the Vosges, and mountain warfare, with illustrations (continued). The war exhibit (continued). Military chronicle: Jurisprudence and the messenger pigeons.

JULY 21. Night marches and encounters. The defense of the Vosges, and mountain warfare (end). The war exhibit at the Exposition of 1889 (ended).

JULY 28. The shelter trench (tranchée-abri), with illustrations in the text. French influence beyond the seas. The military exhibit of 1889. Naval manœuvres, etc. The new regulations for infantry manœuvres; Title V, school of regiment.

AUGUST 4. The army recruitment; law of July 15, 1889. The military exhibit of 1889 (continued), with cuts in the text.

AUGUST 11. The fleet versus coast batteries. The army recruitment; law of July 15, 1889. The military exhibit (continued), with cuts.

AUGUST 18. The fleet versus coast batteries (an answer to the preceding article on the same subject). The army recruitment; law of July, 1889.

AUGUST 25. Leading of columns on a march, and the directing compass (military strategy), with illustrations. The pacific conquest of the African interior. The military exhibit, etc.

SEPTEMBER 1. The army corps of six brigades. The supply train. A few words about the instruction of cavalry troops.

SEPTEMBER 8. The development of the torpedo-boat. First succor to the wounded on the battlefield. Military exhibit, Paris Exposition, 1889.

SEPTEMBER 15. The mountain gun. The development of the torpedo-boat. The civic duties of the soldier and the military duties of the citizen. The military exhibit of 1889 (continued).

SEPTEMBER 22. The military oath in the Russian army. The development of the torpedo-boat. The military exhibit (continued).

SEPTEMBER 29. The "Sud-Oranais" campaign against Bon-Amena in 1881; from the diary of a cavalry officer. The flag. The call of the "réservistes" and the territorials. Principles of hygiene. The military exhibit of 1889. Military chronicle: Letter from the United States, etc. J. L.

REVISTA MILITAR DE CHILE.

NOS. 30–35, MARCH to AUGUST, 1889. Comparison between the Krupp and the De Bange systems, by Lieutenant-Colonel Don J. C. Salvo. Experiments made in foreign countries on the reducing of gun-calibers (continued). The Lebel gun, by Captain Cousiño. De Bange artillery, by Lieutenant-Colonel Don J. C. Salvo. The repeating rifle, and the small-caliber rifle, by A. de P. History of powder, by Lieutenant-Colonel Don R. U. O. J. B. B.

REVISTA MARITIMA BRAZILEIRA.

DECEMBER, 1888, to JULY, 1889. Naval apprentice school. Naval jurisprudence. Naval reforms. Institution of a military school in Brazil. Submarine boats. Neutralization of the Suez Canal. On tempests. Article on explosives. Practical school of artillery. The navigation of the coast. Maritime warfare. The Armstrong rapid-fire guns. Account of cruise of the Rèachuelo in 1888–9. The ironclad Piemonte. Meteorological observations. J. B. B.

REVUE MARITIME ET COLONIALE.

JUNE. Scientific mission to Cape Horn; meteorology (ended). Guadeloupe and its dependencies. Notice on the military organization of the expeditionary corps to Massaouah. Notes on the Fourrier dromoscope and its appliance to the behavior of the compass on board the Duquesne. The English navy budget. A history of the French East India Company.

JULY. A history of the French East India Company (ended). Historical notes on the Gavre committee (continued). Legislation for the French possessions of Madagascar.

AUGUST. Historical studies of the military marine of France; the great fleets of Louis XIV. A study of sextants in regard to excentricity. The cohorts of the Legion of Hònor. Organization of a practical school of artillery in Portugal.

SEPTEMBER, 1889. Perturbation of the compass on the coasts of Iceland. Historical notice on the commission of Gavre. A Breton privateer in the XV century. Regulations for the Academy of the Italian royal navy at Leghorn. The cohorts of the Legion of Honor. Chronicle. The Teutonic as an auxiliary cruiser. Naval constructions in England. Plans of the new American cruisers. Naval manœuvres in England. The German torpedo-boat of pressed paper. J. L.

RIVISTA MARITTIMA.

MARCH, 1889. The Grenfell sight. Submarine vessels (historical).

APRIL. Acquisition and loss of Cyprus, by Vice-Admiral L. Fincati. Economical speed in ships, by Captain D. Bonamico. Report on the English naval manœuvres of 1888.

MAY. Economical speed in ships (continued). Speed trials of the Lepanto. Project for canal from Rome to the Mediterranean. On sheathing metal bottoms (translation of article in No. 48, Proceedings U. S. Naval Institute).

JUNE. Description (with plates) of the Italian cruiser Piemonte. Economical speed for ships (conclusion). The acoustic faculty in seafaring men. Fog signals, by Doctor F. Santini. Armor for ships, by N. Soliani, Italian navy. On sheathing metal bottoms (conclusion).

JULY and AUGUST. Acquisition and loss of Cyprus (continued). Critical study of the port of Barcelona, with notes on the different Mediterranean ports, by E. S. di Tenlada. Coast defense, by C. A. On the penetrability of armor plates. Notes taken at Krupp's establishment. Speed trials of Italian ironclad Lepanto (conclusion). On the development of modern explosives, by D. G. The Society Islands and the natives of Polynesia, by Dr. Filippo Rho. Latest improvements in Thorneycroft torpedo-boats (translation).

J. B. B.

ROYAL ARTILLERY INSTITUTION.

VOLUME XVII, NO. 4. Proposed target for testing uniformity of laying. Plotting board for cross-bearings. The bursting of the 34-cm. gun on board the Amiral Duperré.

NO. 5. The trajectory of a projectile for the cubic law of resistance.

NO. 6. Internal ballistics. Simple-position finding. The 12-pounder shrapnel and its defects. Coast batteries *vs.* fleets.

ROYAL UNITED SERVICE INSTITUTION.

VOLUME XXXIII, NO. 149. Fortifications and fleets. The training of the executive branch of the navy.

NO. 150. The tactics of coast defense. The mariner's compass in modern vessels of war. The mechanical coaling of steamers. The pneumatic torpedo-gun; its uses ashore and afloat. The photographing of artillery projectiles travelling through the air at a high velocity. R. W.

THE SCHOOL OF MINES QUARTERLY.

APRIL, 1889. Western Union time system, by F. R. Bartlett, C. E., and R. P. Miller, C. E. Winding engines, by Herbert W. Hughes, F. G. S.

JULY, 1889. Fuel oil for stationary boilers in New York City, by H. F. J. Porter, M. E.

Committee appointed to consider the best method of establishing international standards for the analysis of iron and steel. British Association for the Advancement of Science, Section B. Committee: Professor Roberts-Austen, F. R. S., Chairman; Sir F. Abel, C. B., F. R. S.; Professor Langley; Edward Riley; G. J. Snelus, F. R. S.; John Spiller; Professor Tilden, F. R. S.; and Thomas Turner, Secretary. *Objects.*—It is proposed that the committee shall co-operate with other similar committees in the more important iron-producing countries, in order to provide standard specimens of iron and steel, the chemical composition of which shall have been carefully determined. The specimens adopted as standards shall be intrusted to some recognized official authority, such as the Standards Department of the Board of Trade, and shall be used for reference in the determination of the accuracy of any proposed method of analysis, or for controlling the results of analyses in any cases of importance which may from time to time arise.

Suggestions.—1. Professor J. W. Langley, of the University of Michigan,

U. S. A., to be requested to superintend the production of the samples; that they be prepared and preserved in accordance with the directions to be furnished by the committee; and that an equal portion of each sample be forwarded to the several secretaries of the respective committees in the United Kingdom, America, France, Germany, and Sweden.

2. The specimens are to be eventually adopted as standards, to be supplied to not more than seven representative chemists of repute in each of the countries above mentioned, who shall be requested to analyze the specimens by any method or methods they may prefer.

3. In the event of the analyses giving results which in the opinion of the committee may be regarded as sufficiently concordant, the means of the analytical results of each of the several constituents to be adopted as representing the composition of the standards. The reports on the analytical results not to be issued before the various analysts to whom the samples have been submitted shall have had an opportunity of examining it. The standards shall hereafter be distinguished only by letters or numbers.

4. The attention of the committee to be for the present confined to four samples of steel, selected as containing as nearly as possible 1.3, 0.8, 0.4 and 0.15 per cent of total carbon respectively. In addition to the determination of the amount of carbon present in each condition, the phosphorus, sulphur, silicon, manganese and chromium also to be determined.

5. 150 kilos of the samples selected for examination as standards to be prepared in all. This would give, after allowing sufficient for the required analyses, quite 5 kilos of each standard for each of the five countries interested, allowing say 10 grams for each applicant who may desire to use the standards. This would permit of 500 appeals to each of the four standards in each country, or at least 10,000 appeals in all.

6. The samples to be analyzed in the United Kingdom by W. Jenkins, Dowlais; Edward Riley, London; J. E. Stead, Middlesbrough; The Royal School of Mines; G. S. Packer, of the Steel Company of Scotland; and two others.

7. The metal of which the samples are to be produced to be cast in small ingots, special care being taken to prevent any irregularity of composition. After the removal of the outer skin, the metal to be cut by a blunt tool in the form of thin shavings, then crushed, sieved, and intimately mixed.

8. The samples thus prepared to be preserved in separate small quantities (say of 30 grams each), which shall be hermetically sealed in glass tubes, so as to prevent oxidation.

9. These preliminary arrangements of the committee to be communicated to the leading technical journals.

F. H. E.

THE STEAMSHIP.

JULY, 1889. Marine engine economy. Mechanical refrigeration. Electric lighting. Coal and combustion. The speed of steamships.

AUGUST. Additions to the British navy. American opinion of twin-screw steamers. Combined indicator cards of triple-expansion engines. Experimental aid in the design of high-speed steamships. Thompson's combined circulator and feed-water heater. Electric lighting. Cranks and screw-shafts in the mercantile marine.

SEPTEMBER. The naval review of 1889. Expansion of steam. Illustrations and description of the U. S. S. Baltimore. Drawings and description of the Merton valve gear, with its application to ships of recent design.

J. K. B.

TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.

FEBRUARY, 1889. New York meeting. The influence of silicon in cast-iron, by W. J. Keep.

TRANSACTIONS OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS.

MAY, 1889. On flood heights in the Mississippi river, by William Starling.

JUNE. Some experiments on the strength of Bessemer steel bridge compression members, by James G. Dagron.

JULY. American railroad bridges, by Theodore Cooper.

TRANSACTIONS OF THE CANADIAN SOCIETY OF CIVIL ENGINEERS.

VOLUME II, PART II, OCTOBER to DECEMBER, 1889. Inception of electrical science and the evolution of telegraphy, by F. N. Gisborne. A mine pump working under a heavy pressure, by H. S. Poole.

TRANSACTIONS OF THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

MARCH, 1889, PART I AND II. The danger attending the use of light mineral oils for lubricating air-compressing machinery, by John Morrison.

F. H. E.

TRANSACTIONS OF THE NORTHEAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

VOLUME V. The use of machinery in construction. A new system of shipbuilding to facilitate the application of machine riveting to shell plating. A new wave-motor. The structural strength of cargo steamers. The development of the "well-deck" cargo steamer. Corrosion and pitting in marine boilers. The proper capacity of air pumps.

THE UNITED SERVICE.

VOLUME II, NO. 4. The Canadian question. Nautical proverbs and sayings. The Nez Perce War. Old uniforms of the United States service. From bars to stars. The Royal Irish Constabulary.

NO. 5. Soldier or granger. The United States Revenue Cutter Service. An incident of Fredericksburg. The mobilization of the fleet. Chronicles of Carter Barracks. The English naval manœuvres. Some military reminiscences of the Rebellion.

NO. 6. The evolution of the torpedo-boat. Our view of the army question. The United States Revenue Cutter Service. A fair Georgian. The annual inspection of the National Guard by army officers. A remarkable episode of the late war.

UNITED SERVICES GAZETTE.

JULY 6, 1889. Her Majesty's ship Sultan. Probationary assistant engineers, R. N. The escape of the Calliope. The pneumatic dynamite gun. The Sultan inquiry.

JULY 13. The Sans Pareil. The Warspite. The mobilization of the fleet. Saving life at sea. An English rival port to Delagoa Bay. Controllable torpedoes. A suggestion for the Admiralty.

JULY 20. The naval manœuvres. Ships building. The Royal Naval School. Dock-yard apprentices.

JULY 27. Naval inspection of the squadrons mobilized for the manœuvres. Ships building and to be built. The naval review. The programme of the naval manœuvres. Quick-firing guns—I. The Royal United Service Institution. Naval reviews.

AUGUST 3. The Royal Naval School. The Thames Nautical Training College. The naval review. Quick-firing guns—II. The stoker question.

AUGUST 10. The naval manœuvres. The lords of the Admiralty at Portsmouth. The German Emperor and the Royal Yacht Squadron. Continental systems of coast defense.

AUGUST 17. The naval manœuvres. The Royal United Service Institution.

AUGUST 24. The Naval Annual. The case of Admiral the Earl of Dundonald. The naval manœuvres. Coaling stations. The boiler question.

AUGUST 31. Outline of a scheme for the naval defense of the American coast—I.

This is the first of a series of papers on the lecture of Capt. Sampson, U. S. N., published in No. 49 of these Proceedings.

The medical officers of the army and navy. Navy surgeons. The naval manœuvres. The raising of the Sultan. The lords of the Admiralty at Plymouth. Coaling ship.

SEPTEMBER 7. Outline of a scheme for the naval defense of the American coast—II. Lessons to be learned from the naval manœuvres of 1889.

SEPTEMBER 14. Launch of war-ships. Sailors' rations.

SEPTEMBER 17. The bombardment of unfortified, unresisting cities. Torpedo-boats for the British Government. The Engine-room Department, Royal Navy.

SEPTEMBER 28. Outline of a scheme for the naval defense of the American coast—III. The loss of the Lily. The Engine-room Department, Royal Navy.

OCTOBER 5. Lord Armstrong on quick-firing guns and smokeless powder. Smokeless powder.

OCTOBER 12. The late naval manœuvres. The nature and cause of the resistance of water. A suggested new form of steam vessel to attain high speed. The navy. Authoritative service opinions.

OCTOBER 19. Sailors' rations—II.

OCTOBER 26. Torpedo-thrower. R. W.

LE YACHT.

JULY 6, 1889. Editorial on the French navy. Discussion on the annual appropriation in the Senate. The manœuvres in the Mediterranean. Review of the merchant marine. The influence of speed in ramming collisions (ended).

JULY 13. Notes from foreign shipyards.

JULY 20. The French manœuvres of 1889. Review of the merchant marine.

JULY 27. The French manœuvres of 1889. The naval exhibit at the Paris Exhibition.

AUGUST 3. Editorial on the annual appropriation of 58,000,000 francs.

AUGUST 10. Remarks on the naval review at Spithead. Review of the merchant marine.

AUGUST 17. The naval exhibit at the Paris Exhibition. Trial trip of the Trafalgar.

AUGUST 24. Editorial on the English manœuvres. The naval exhibit at the Paris Exhibition.

AUGUST 31. The English navy. Modern engines.

SEPTEMBER 7. Notes from foreign shipyards. Review of the merchant marine.

SEPTEMBER 14. The loss of the "Anadyr" and the responsibility of pilots. English squadron manœuvres. A. C. B.

REVIEWERS AND TRANSLATORS.

Lieut.-Comdr. E. H. C. LEUTZÉ,	Lieut. A. C. BAKER,
Lieut. J. B. BRIGGS,	Prof. JULES LEROUX,
P. A. Eng. J. K. BARTON,	Prof. H. MARION,
P. A. Eng. F. H. ELDRIDGE,	Prof. C. R. SANGER.

OFFICERS OF THE INSTITUTE.

1890.

Elected at the regular annual meeting, held at Annapolis, Md.,
October 18, 1889.

PRESIDENT.

REAR-ADMIRAL S. B. LUCE, U. S. N.

VICE-PRESIDENT.

COMMANDER W. T. SAMPSON, U. S. N.

SECRETARY AND TREASURER.

LIEUTENANT RICHARD WAINWRIGHT, U. S. N.

BOARD OF CONTROL.

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LIEUTENANT-COMMANDER CHAS. SPERRY, U. S. N.
LIEUTENANT-COMMANDER E. H. C. LEUTZÉ, U. S. N.
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P. A. ENGINEER F. H. ELDRIDGE, U. S. N.
PROFESSOR N. M. TERRY, A. M., PH. D.
LIEUTENANT RICHARD WAINWRIGHT, U. S. N. (ex officio.)

The following amendment to the Constitution, to replace Article XI, Sections 1 and 2, was duly carried according to the forms prescribed in the Constitution, by a majority vote:

SEC. 1. A prize of one hundred dollars, with a gold medal, shall be offered each year, for the best essay on any subject pertaining to the Naval Profession.

SEC. 2. The award for the above-named prize shall be made by the Board of Control, voting by ballot and without knowledge of the names of the competitors; and the time and manner of submitting such essays shall be determined and announced by said Board.

SPECIAL NOTICE.

NAVAL INSTITUTE PRIZE ESSAY, 1890.

A prize of one hundred dollars and a gold medal is offered by the Naval Institute for the best Essay presented, subject to the following rules:

1. Competition for the Prize is open to all members, Regular, Life, Honorary, and Associate, and to all persons entitled to become members, provided such membership be completed before the submission of the Essay. Members whose dues are two years in arrears are not eligible to compete for the Prize until their dues are paid.

2. Each competitor to send his essay in a sealed envelope to the Secretary and Treasurer on or before January 1, 1890. The name of the writer shall not be given in this envelope, but instead thereof a motto. Accompanying the essay a separate sealed envelope will be sent to the Secretary and Treasurer, with the motto on the outside and writer's name and motto inside. This envelope is not to be opened until after the decision of the Judges.

3. The Judges shall be three gentlemen of eminent professional attainments (to be selected by the Board of Control), who will be requested to designate the essay, if any, worthy of the Prize, and, also, those deserving honorable mention, in the order of their merit.

4. The successful essay to be published in the Proceedings of the Institute; and the essays of other competitors, receiving honorable mention, to be published also, at the discretion of the Board of Control; and no change shall be made in the text of any competitive essay, published in the Proceedings of the Institute, after it leaves the hands of the Judges.

5. Any essay not having received honorable mention, may be published also, at the discretion of the Board of Control, but only with the consent of the author.

6. The Board of Control will accept any essay written upon a subject closely related to the Naval Profession.

7. The essay is limited to fifty (50) printed pages of the Proceedings of the Institute.

8. All essays submitted must be either type-written or copied in a clear and legible hand.

9. The successful competitor will be made a Life Member of the Institute.

10. In the event of the Prize being awarded to the winner of a previous year, a gold clasp, suitably engraved, will be given in lieu of a gold medal.

By direction of Board of Control.

RICHARD WAINWRIGHT,
Lieut., U. S. N., Secretary and Treasurer.

ANNAPOLIS, MD., *February* 8, 1889.

SPECIAL NOTICE.

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RICHARD WAINWRIGHT,
Lieut., U. S. N., Secretary and Treasurer.

ANNAPOLIS, MD., *February* 8, 1889.

NOTICE.

Owing to an unavoidable delay in receiving the decision of the judges, it has been deemed advisable to print the Prize Essay, without discussion, in the present number of the Proceedings.

The meeting for the discussion of the Essay at Annapolis, Md., will be held on October 14, 1887. The Corresponding Secretaries will hold meetings at their respective Branches for the discussion of the Essay at any convenient date, not later than October 14th. Members not able to attend any of the meetings may take part in the discussion by forwarding their remarks in manuscript to the Secretary and Treasurer, or to the Corresponding Secretary of any Branch, not later than October 13, 1887.

All MSS. of the discussion must be forwarded from the Branches to the Secretary and Treasurer before October 20, 1887.

By direction of the Board of Control.

CHAS. R. MILES, *Lieut., U. S. N.,*
Secretary and Treasurer.

NEW YORK, *May* 19, 1887.

SECRETARY, NAVAL INSTITUTE, ANNAPOLIS, MD.

Dear Sir: After examination of the five essays upon the Naval Brigade, submitted to us for decision, we have the honor to state that we consider the essay bearing the motto "In hoc signo vinces,"* entitled to the prize.

In our opinion the remaining essays stand in the following order of merit:

First—"He who can get more from his men than can his opponent from his, is always at an advantage." † Deserving honorable mention.

Second—"Aut nunquam tenta aut perfice." ‡ Deserving honorable mention.

Third—"J'ai pris mon parti."

Fourth—"Necessity is the mother of invention."

Respectfully submitted,
J. S. SKERRETT,
Captain, U. S. N.
CHARLES HEYWOOD,
Major and Brev. Lt. Col., U. S. M. C.
J. W. MILLER.

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* By Lieut. C. T. Hutchins, U. S. N.

† By Lieut. T. B. M. Mason, U. S. N.

‡ By Ensign Wm. Ledyard Rodgers, U. S. N.

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5. Any essay not having received honorable mention, may be published also, at the discretion of the Board of Control, but only with the consent of the author.

6. The subject for the Prize Essay is, *Torpedoes.*
   - I. *Their place in naval warfare.*
   - II. *Character of the torpedoes and torpedo vessels required for the naval service of the United States.*
   - III. *Organization of our naval torpedo service and instruction of its personnel.*
   - IV. *Tactics to be employed in offensive and in defensive warfare.*

7. The essay is limited to fifty printed pages of the Proceedings of the Institute.

8. The successful competitor will be made a Life Member of the Institute.

9. In the event of the Prize being awarded to the winner of a previous year, a gold clasp, suitably engraved, will be given in lieu of a gold medal.

By direction of Board of Control.

CHARLES R. MILES,
Lieut., U. S. N., Secretary and Treasurer.

ANNAPOLIS, MD., *January* 1, 1887.